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TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
Interlocking Steel and Concrete Pile Construction for Seawalls and Foundation Work (illustrated)	117
Concrete Sewers at Richmond, Ind.; Frederick R. Charles	118
Recent Records of High-Duty Water-Works Pumping Engines (illustrated)	120
Annual Convention of the Wood Preservers' Association	121
Emergency Repairs to a Bascule Drawbridge Over the Chicago River; Chicago Terminal Transfer Ry. (illustrated); F. H. Avery	123
Strengthening Tracks for Higher Train Speeds (illustrated); M. L. Byers, M. Am. Soc. C. E.	126
Annual Convention of the Illinois Society of Engineers and Surveyors	131
Treating Timber with Crude Petroleum; C. M. Taylor	132
Preliminary Report of the United States National Waterways Commission	136
Progress of Excavation and Construction on the Panama Canal (illustrated)	142
Annual Meeting of the Canadian Society of Civil Engineers	143
H. N. Ruttan, President of the Canadian Society of Civil Engineers (with portrait)	144
A Slide Rule for Reinforced-Concrete Slabs (illustrated)	150

	Page.
EDITORIAL	133
Report of the National Waterways Commission—The Paris Flood—Municipal Ownership of Water-Works at San Francisco—A Warning to Eastern Engineers and a Comment on Dam Construction—The Suicidal Policy of Certain American Cities—The Influence of Colleges upon the Government of Small Towns—Duty Tests vs. Service Performance—A New Way to Destroy the Forests.	
The Improvement of Living Conditions in Construction Camps	135
LETTERS TO THE EDITOR	135
Ice Stoppages of Water-Works Intakes; Rudolph Hering—The Yield of Two Ponds Without Visible Outlet; Water Supply of Plymouth, Mass.; Arthur S. Blackmer—Solution of the Crossover with Tapered Curves (illustrated); H. M. Lull; C. M. Kurtz—Notes and Queries.	
ENGINEERING NEWS OF THE WEEK	151
PERSONALS	152
ENGINEERING SOCIETIES	152

Interlocking Steel and Concrete Pile Construction for Seawalls and Foundation Work.

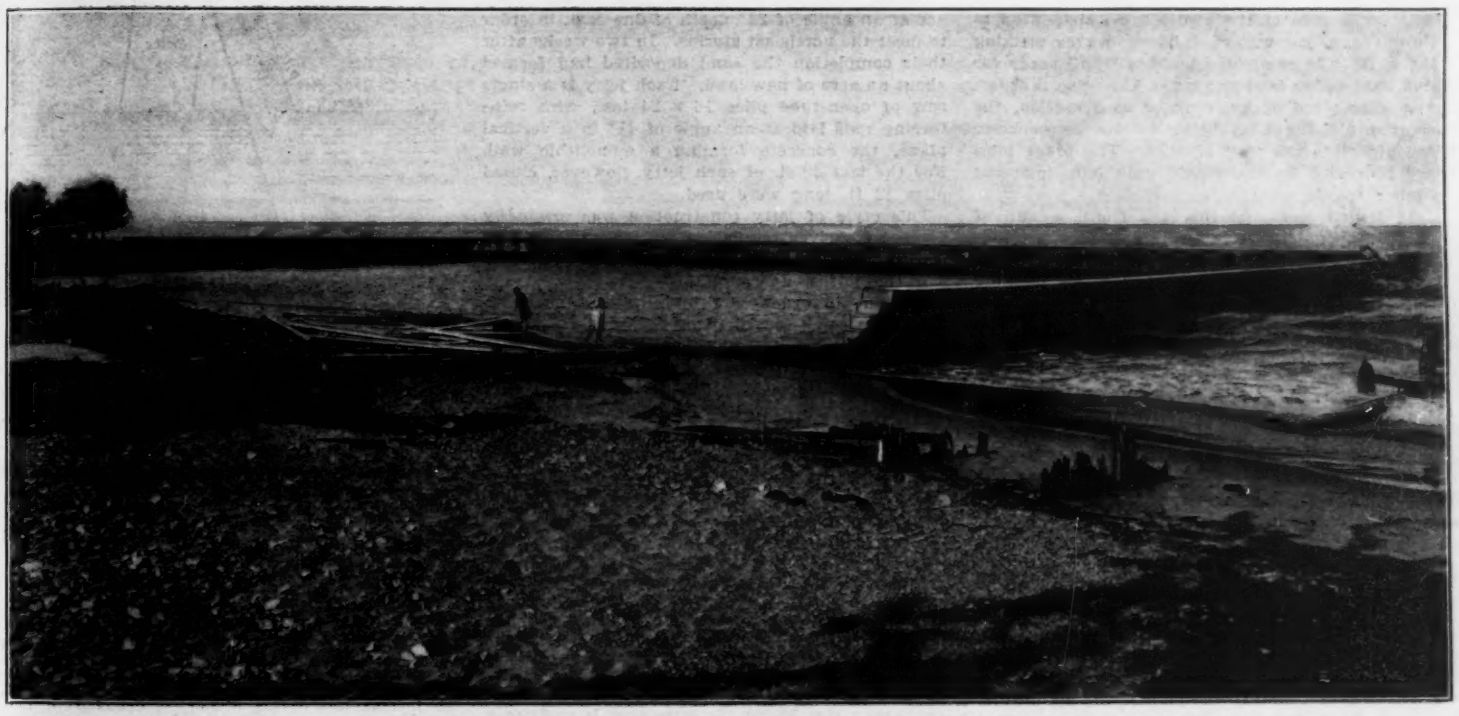
A new system of interlocking pile construction has been used recently in Chicago for protective work and jetties on the lake shore and for the foundations of buildings. The construction is such that the completed work forms a solid and continuous wall. The process consists in sinking steel tubes by jetting and loading, and then filling them with concrete. Each tube or cylinder has on one side a hollow vertical rib and on the other side a hollow vertical socket, both of dovetail form; the rib of one pile enters the groove of the other and the piles are thus locked together. As the rib and groove are hollow and form a part of the tube, the separate concrete piles in the tubes are locked together, also, and do not depend upon the steel shell to lock the piles together.

For land work, the cylinders are open at the bottom, and the faces of the rib and groove are open (the sides being tied together by transverse strips). With this arrangement, the concrete filling forms a monolithic mass (above the surface of the ground), and may have horizontal and diagonal reinforcing rods embedded within it. This arrangement is used also in water where there is no danger of scouring. In this case, the tube does not displace the material, and the concrete filling does not extend below the bottom of the lake or river.

For work in the water, and exposed to the action of waves and currents, the tube has a closed flat bottom and closed faces to the rib and groove, so that the concrete filling forms a separate pile, interlocking with the adjacent piles, and reinforced by vertical rods as may be required. In Fig. 5 are shown the sections of the two types of tubes. The standard size is 20 ins. diameter, and the shells are built of No. 24 black sheet steel, reinforced by interior rings of steel or malleable iron. They may be made of any desired length.

In the construction of work with the closed piles, a timber pile is put down at the starting point, and has on its face a steel groove to receive the rib or tongue of the first steel tube. The tube is swung into position by a crane or derrick, and the bottom of its tongue is inserted into the false groove on the timber pile. It is then lowered until it reaches the water, and the concrete filling is commenced, causing the tube to sink. The top of this filling is kept about 12 to 24 ins. above the water level. When the pile reaches the bed of the lake or river the sinking is assisted by water jets, and the tube put down to the required depth. The next tube is sunk in the same way. The work of putting down the tubes is shown in Fig. 2. The concrete filling for the upper part of the tubes may be deferred until a number of tubes are in place. The piles have flat bottoms, and no pile driver is used. In very stiff ground, the sinking of the tube may be assisted by transferring to it the weight of a water tank used in connection with the sinking jets.

The open tubes are sunk in much the same way, but of course without concrete filling. The resistance is much less, as only the edge of the shell penetrates the material. When the tubes have been placed for a certain length of work, the longitudinal steel bars (horizontal or diagonal) are placed in position, and the concrete filled in to form a wall from the level of the ground to the top of the steel tubes. The timber end pile in this case is fitted with a steel rib or tongue instead of a groove, so that each pile has its tongue forward when the concrete is deposited. The purpose of this is to make the weight of concrete spread or spring the steel sides of the tongue outward and force them into tight contact with the groove of the adjacent pile. This prevents any leakage of cement or concrete at the joint. The end or closing pile of any piece of work has only a tongue (or groove) on one side, the other side having a cylindrical surface.



COMPLETED BULKHEAD WALL OF INTERLOCKING STEEL AND CONCRETE PILES ON THE LAKE FRONT, AT CHICAGO.

A modified design of the pile has an oval shell 16 × 24 ins., and this shape has been used for 575 ft. of wall enclosing a plot of ground on the shore of Lake Michigan, at Thorndale Ave. and Sheridan Drive, Chicago. A line of 12-ft. piles at each end, at right angles to the main wall, serves to retain the sand filling which was discharged into the enclosed space by a suction dredge. The made ground was used as a building site. This work is shown in Figs. 3 and 4. The piles in this case are inclined, the proper slope being given by two waling timbers against which the shell rested while being driven. At each seventh pile, also, there is an inside brace

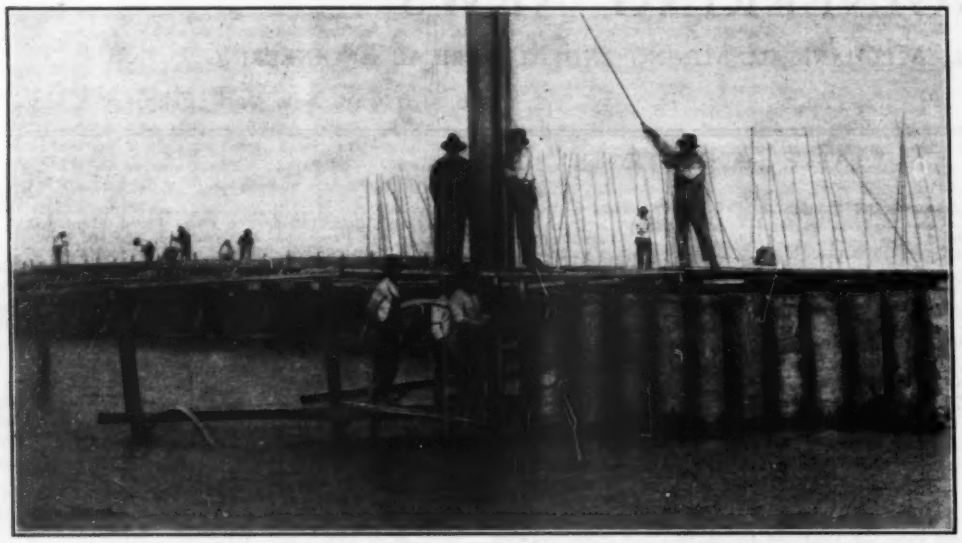


FIG. 2. SINKING STEEL SHELLS FOR THE CONCRETE PILES FORMING A BULKHEAD WALL ALONG THE SHORE OF LAKE MICHIGAN, AT CHICAGO.

pile 12 × 24 ins., inclined in the opposite direction. The wall piles are 16 ft. long, and the brace piles 12 ft. long. Upon the top of the wall is built a concrete girder 36 ins. thick and 4 ft. wide, bonded to the concrete piles by vertical rods. The face of the girder is so shaped as to throw back the water of heavy waves striking the wall. The completed bulkhead wall ready for this sand filling is shown on p. 117. Fig. 6 shows a similar piece of work under construction, the short projecting bars being to tie the concrete cap girder to the wall of piles. The brace piles are concealed by the plank walk laid upon the timber trestle used in construction.

At Devon Ave. and the lake front, a wall of piling 650 ft. long, was built to enclose a building site for Mr. A. G. Wheeler. After the site had been filled, the foundations of the building

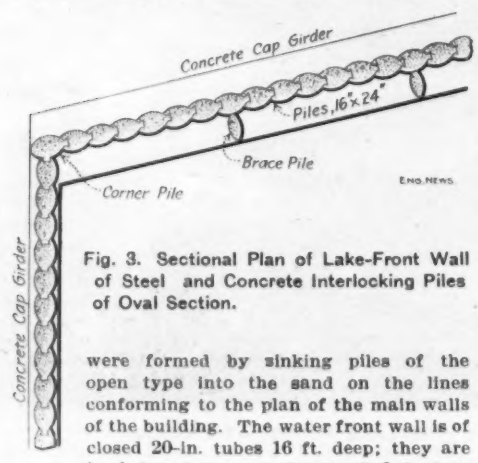


Fig. 3. Sectional Plan of Lake-Front Wall of Steel and Concrete Interlocking Piles of Oval Section.

were formed by sinking piles of the open type into the sand on the lines conforming to the plan of the main walls of the building. The water front wall is of closed 20-in. tubes 16 ft. deep; they are in 4 ft. of water and extend 6 ft. into the bed of the lake, leaving 6 ft. above the water. Every ninth pile is backed by two vertical piles which form brace piles and support the concrete girder. This girder is 6 ft. wide and 2 ft. 6 ins. thick. Upon this was built a second girder of the same width and 2 ft. thick. This work (without the upper girder) is shown in Fig. 7, and the finished work in Fig. 8.

At Hollywood and Ardmore Aves., a site has been reclaimed by a 150-ft. wall composed of a single row of the 16 × 24-in. piles. South of this work a site 75 ft. wide has been enclosed by a wall of similar construction, the side walls being 30 ft. long. In this case the end and side walls form the foundations for an automobile shed or garage.* This is the work shown in Fig. 2, the long steel rods being for the purpose of reinforcing the walls of the building and anchoring them to the concrete bulkhead wall formed by the piles. All the bulkhead walls described above are exposed to heavy wave action during storms on Lake Michigan.

An interesting application of this system of construction is for jetties on the lake shore at Rogers Park, built for the Park Board of that place. There are seven jetties, extending 125 ft. to 150 ft. from the shore, and spaced 80 ft. apart. They are at an angle of 22° north of due east, in order to meet the northeast storms. In two weeks after their completion the sand deposited had formed about an acre of new land. Each jetty is a single row of open-tube piles 16 × 24 ins., with reinforcing rods laid at an angle of 45° in a vertical plane, the concrete forming a monolithic wall. For the last 20 ft. of each jetty, however, closed piles 12 ft. long were used.

This style of jetty construction was originally devised for river regulation and shore protection work on the Mississippi River. The plan was to run the jetties upstream at an angle with the shore line in order to form still-water bays in which the sand and silt would be deposited.

The system of steel and concrete pile construction described above has been invented and patented by Mr. Henry W. Schlueter, of Chicago, and the patents are owned by the Interlocking Tube Co., 79 Dearborn St., Chicago. The construction work is carried out by the Interlocking Concrete Construction Co., of the same address, of which Mr. Wm. H. Mulholand is President. Mr. Schleuter is engineer for both companies.

GOVERNMENT LAND DRAINAGE in Nova Scotia is under consideration by the Provincial Department of Agriculture. The plan that seems to be favored is to have the work carried out by and at the cost of the Provincial Government, the farmer to pay 7% on the cost for a period of 25 years, thus taking care of interest and sinking-fund charges. It is stated that a similar plan has been in use in Australia and New Zealand, except that 5% on the investment is paid for a period of 36 years.

Concrete Sewers at Richmond, Ind.*

By FREDERIC R. CHARLES.†

The sewerage system we have just built employs concrete for diameters of 54, 48, 42 and 36 ins., and vitrified pipe for smaller sizes. We find that concrete approaches the cost of vitrified pipe at the 24-in. size, and below that we prefer the pipe. Our former experience indicated that in the interests of economy some change might be made in the design that would still leave abundant strength. Accordingly the thickness of the shell was reduced slightly, and the reinforcement was omitted from the lower portion of the sewer, where built on a good, solid foundation.

The "Kahn" rib-metal was used for reinforcing. We found it easier to handle than expanded metal, and the size and shape of the spaces between the ribs offer more room for the insertion of a stick or tamp to settle the concrete around the metal and the forms, which operation is very necessary in order to obtain solid concrete and a smooth surface. The metal is bent at the mill to such a curve that when placed it will be 2 ins. from the inner surface of the concrete at the crown, and 2 ins. from the outer surface at the springing line. For spacing and maintaining it in place wooden strips are placed

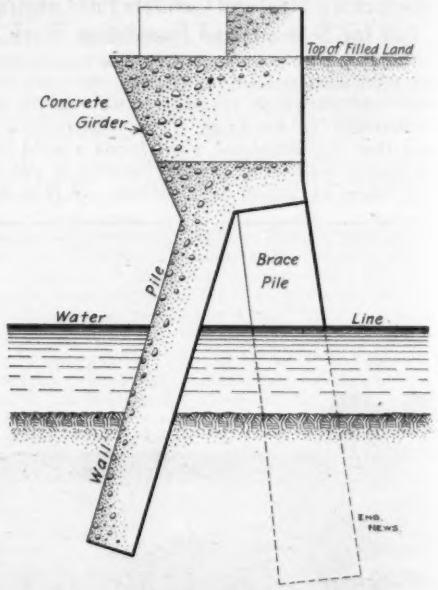


Fig. 4. Section of Lake Front Wall of Steel and Concrete Pile Construction at Thorndale Ave. and Sheridan Drive, Chicago.

between the metal and the form, and removed as the concrete is laid. The thickness of shell and the metal used are as follows:

Inside diam., ins.	Thickness, ins.	Length of metal sheet, ft.
36	4	7
42	4	8
48	5	9
54	5	10

In leaving openings for house connections, at first we built in the ordinary vitrified slant or thimble, but we

*Abstract of a paper read at the annual meeting of the Indiana Engineering Society at Indianapolis, Ind., Jan. 13.

†City Engineer, Richmond, Ind.

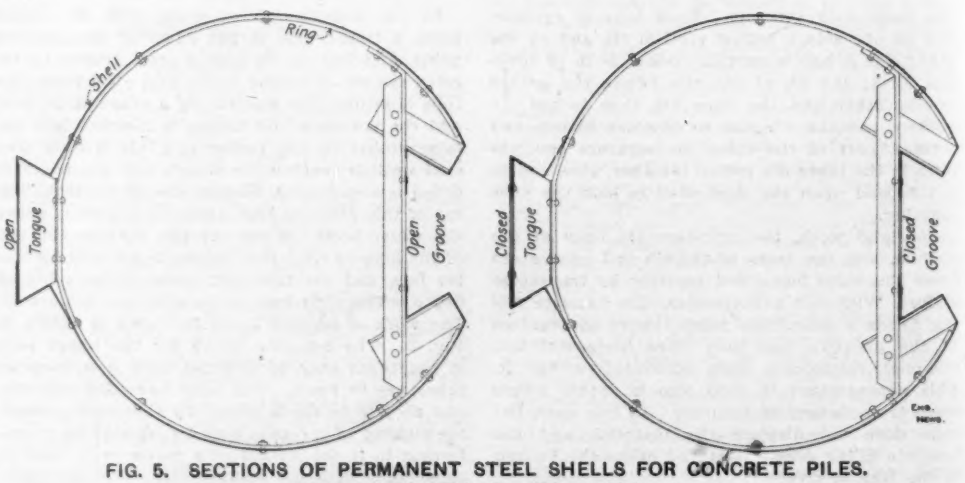


FIG. 5. SECTIONS OF PERMANENT STEEL SHELLS FOR CONCRETE PILES.
(The Interlocking Tube Co., Chicago; Makers.)

were troubled by breaking so many of the projecting rings or flanges by falling rocks, etc., that finally openings were merely left in the concrete shell by the use of a core or center, devised by Mr. D. B. Davis, Inspector on the work. This core consists of two concentric circle blocks of hard wood nailed together; one is 8 ins. diameter and 2 ins. thick; the other is 6 ins. diameter and 3 ins. thick. Placed in the concrete shell, this device makes a flange suitable for receiving the end of the house connection pipe, and is easily removed when the concrete is hard.

According to our experience, the concrete for the lower half of the sewer should be mixed very wet, so that it will flow to place under and around the form. For the upper half it should be less fluid, having enough moisture to make a stiff, jelly-like mass, in order that it may retain its place on the arch without flowing off. For the flow line, the proper consistency is an average between the two. Our method of construction is to first shape the trench to the approximate shape and dimension of the outside of the sewer, allowing for the thickness of the shell; then to lay a strip of the flow line about 2 ft. wide. This is cut off to the proper line and radius by straight edges drawn over heavy wooden blocks of the like radius, put 12 ft. or 16 ft. apart, and withdrawn and moved ahead when the concrete reaches them.

For forms, we prefer the full circle, by which the whole sewer above the flow line can be built in one operation. On this last work we used the special centers manufactured by the Adjustable Steel Centering Co., of Fond du Lac, Wis. All parts are easy of access, so that they can be handled quickly and easily, an important item in considering the cost of work. At the beginning, to release, move to section ahead, and set up the centers, anchor them securely and place reinforcing material ready for the concrete, took about 13 labor hours, four men working 3¼ hours. After some experience this time was reduced to 10 labor hours. This is for 35 ft. of sewer, as the centers are made in 6-ft. lengths, and six of these sufficed for our needs. These, with the necessary lap, provided for 35 ft. of sewer.

After the gang became organized and the work systematized, the schedule of the day's operation was as follows: (1) releasing centers from the previous day's work, and moving them forward onto the flow line, prepared the preceding day; this would take until about 9 a. m. (2) Concreting the barrel of the sewer, which was usually finished by noon or a little after. (3) Laying the concrete on the flow line ahead for the next day's work, which would take about half an hour. For hand-mixed concrete, the mixing boards were placed at the side of the trench, and the concrete shoveled directly into the sewer, without extra handling.

Hand-mixing required a gang of seven men, not including superintendence, and for building 35 ft. of sewer, about 50 labor hours were needed. Machine mixing required a larger gang at one time, but the total number of labor hours was less in the aggregate, being only about 40 labor hours, and, of course, saving the cost of superintendence for that time also. With the machine, 12 men composed the gang: 4 or 5 wheelers, 3 or 4 shovelers, 1 helping dump wheelbarrows, 1 removing spacing sticks from reinforcement and keeping same in position, 1 spreading concrete to approximate thickness over the arch and tamping or jostling it around and under the centers, and finally a finisher who gages it to proper thickness, and fills all voids and smoothes the surface by use of a float or a flat, square-pointed shovel. The average cost of this sewer by this method is given in the accompanying table:

COST PER LIN. FT. OF CONCRETE SEWERS AT RICHMOND, IND.

Diam. of sewer	54 ins.	48 ins.	42 ins.
Thick. of shell	5 ins.	5 ins.	4 ins.
Cement quantity	0.347 bbl.	0.29 bbl.	....
Cement, $1.25 per bbl	$0.434	$0.362	$0.250
Gravel, 80 cts. per yd.	.026	.170	.118
Rib metal*	.300	.250	.240
Forms	.125	.115	.115
Labor, 20 cts. per hour.	.230	.186	.188
Total cost, excl. of machine and superintendence	$1.349	$1.083	$0.911

*Metal sheets 10 ft. long in the 54-in. sewer, 9 ft. in the 48-in. and 8 ft. in the 42-in.

The cost is very much less than for a brick sewer for us, and is also less than that of reinforced concrete pipe, which we have used previously. Our experience would indicate that in ordinary cases the monolithic construction is the cheaper, and with the carefulness in regard to workmanship and materials, that is necessary in all concrete construction, it can be made first-class in respect to smoothness and durability. With the use of properly graded aggregate and sufficient quantity of cement, it can be made more nearly watertight than the pipe, with its numerous joints, which are difficult to cement absolutely tight. But the monolithic requires the laying of a subdrain pipe to keep the water away from the fresh concrete, which adds somewhat to the cost, although this subdrain is an advantage also with the concrete pipe sewers. We use this on all our large sewers. An ordinary 6-in. soft tile carries away large quantities of water, and does not add much to the cost.

The pipe requires a trench several inches wider than the monolithic, as for the former we must have room to tamp around it, while with the latter the trench is only made to the size of the exterior of the sewer. This is a considerable saving to the credit of the monolithic. The monolithic is doubtless more solid, as it is built right up against the walls of the trench, while it is extremely difficult to tamp under and around the quarters of the pipe, which, however, must be done to insure strength and stability. But when it is desired to have the backfilling follow closely the building of the sewer, pipe has the advantage, since with the monolithic weight should not be put on until it is thoroughly set.

Our conclusions are that both systems have a field of usefulness, and the better one to use must be decided by local conditions and circumstances. Reinforced concrete can be employed to advantage in sizes from 24 ins. up; below that size the vitrified pipe is preferable, although some excellent concrete pipe is made in smaller sizes. have been informed by Mr. J. C. Butler, City Engineer of Plymouth, Ind., that they have 8-in. to 30-in. concrete pipe sewers, over 20 years old and still in splendid condition.

FIG. 6. BULKHEAD WALL OF INTERLOCKING STEEL AND CONCRETE PILES, READY FOR THE CONCRETE CAP OR GIRDER.

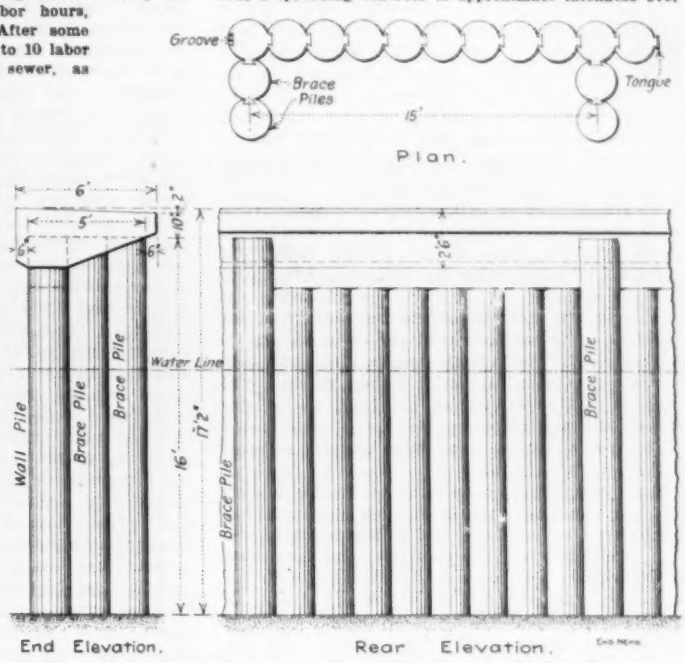


FIG. 7. LAKE FRONT WALL OF STEEL AND CONCRETE INTERLOCKING PILES AND BRACE PILES.

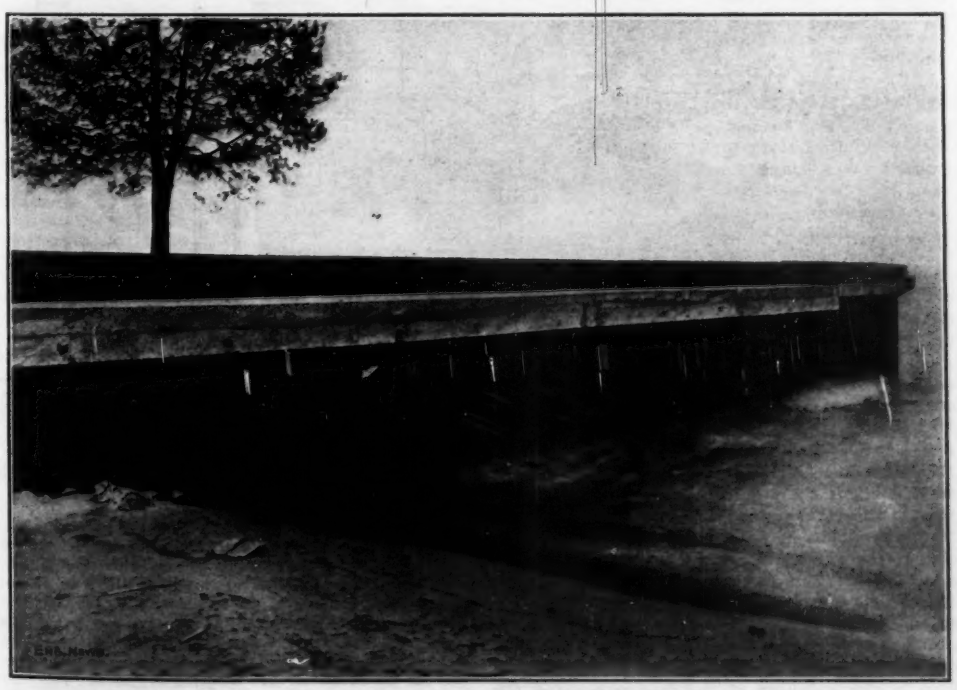


FIG. 8. RECLAIMED LAND FORMED WITHIN BULKHEAD WALLS OF STEEL AND CONCRETE PILES, WITH CONCRETE CAPPING GIRDER.

Recent Records of High-Duty Water-Works Pumping Engines.

The efficiency of water-works pumping engines has been developed to a very high degree, and in recent years some very high records have been made, both in duty tests and in station duty or service performance. We give herewith the results of duty tests on engines at Albany, N. Y., and Milwaukee, Wis., and also of an exceptionally high record for station duty at the latter place.

Duty Test of Pumping Engines at Albany, New York.

Two new engines of the triple-expansion type, built for the Department of Public Works by the Holly Mfg. Co., were tested in June, 1909. The tests were conducted by Mr. Henry A. Allen, consulting engineer (of Chicago), representing the city, and Mr. Rodney D. Hall, representing the builders. For particulars of the tests we are indebted to Mr. Wallace Greenalch, Assoc. M. Am. Soc. C. E., Commissioner of Public Works. The duty of 183,115,000 ft.-lbs. per 1,000 lbs. of dry steam, attained by engine No. 1, is said to be the highest duty yet attained by a pumping engine using jet condensers.

Each engine was guaranteed to develop a duty (on test based on plunger displacement) of 175,000,000 ft.-lbs. per 1,000 lbs. of steam 98½% dry. The high-pressure, intermediate and low-pressure cylinders are respectively 28, 54 and 80 ins. diameter; plungers, 25 ins. diameter; stroke, 60 ins. The flywheels are 18 ft. diameter, mounted on a 19-in. crank shaft. The suction and discharge pipes are 30 ins. diameter. The use of a jet condenser to each engine necessitated making a test of boiler leakage, in addition to weighing the water supplied to the boilers during each test; this was conducted for 12 hours, and showed a leakage of 181.875 lbs. of water per hour. The general results of the test are summarized in Table I.

Test Duty and Station Duty of Pumping Engines at Milwaukee, Wis.

The two latest engines in the North Point pumping station of the Milwaukee city water-works are vertical triple-expansion condensing engines of the direct-acting, crank and flywheel, three-plunger type. They were designed to pump 20,000,000 gals. per 24 hours, when running at 20 r. p. m., against a pressure of 67 lbs. and with a steam pressure not exceeding 125 lbs. at the throttle. They have cylinders 30, 52 and 80 ins. diameter; plungers, 33¾ ins. diameter; stroke, 60 ins. The engines were built by the Wisconsin Engine Co. The first (No. 5) was installed in 1906 and the second (No. 6) in 1908.

Each engine has three double-acting steam cylinders and three single-acting water plungers. The reciprocating parts are of such weight as to equalize the work of the upward and downward strokes, thus enabling the double-acting steam piston to drive the single-acting plunger without special assistance from the flywheels. Between the steam cylinders and the pumps is the crank shaft, with cranks set at 120°, each crank connected to the crossheads by a connecting rod. Each cylinder has a single piston rod carrying the crosshead, while four rods connect the crosshead with the plunger.

The pumps are placed in a dry well, so that there is a lift on the suction side. In each case the suction pipe is 30 ins. diameter, with a 36-in. bell-mouth opening in a 5-ft. tunnel. The discharge pipe is 30 ins. diameter, connecting with a 42-in. pipe at the wall of the building. On the suction and discharge side of each pump is a cast steel diaphragm containing 235 valves of medium-hard rubber 3½ ins. diameter, giving 1,255 sq. ins. of valve area. The diaphragm has 11 cages, eight of which contain 20 valves each, while three contain 25 valves each. The total number of valves in the pumps is 1,410. This arrangement of the valves is shown in Fig. 1, while Fig. 2 shows some of the diaphragms and cages containing the valves.

In the second engine, which is practically a duplicate of the first, the admission valves of all the cylinders, and the exhaust valves of the high pressure and intermediate cylinders, are of the Corliss type. The exhaust valves of the low-pressure cylinder are poppet valves and when closed are flush on the inside of the cylinder head, thus eliminating any clearance due to exhaust ports. All the valve ports are located in the cylinder head. The steam and exhaust valves are worked by separate eccentrics. The governor is of the ordinary fly-ball type, with special arrangement for controlling this style of engine. It is connected to the high-pressure mechanism only, and controls the engine only at maximum speed. The other cut-offs are operated by hand.

The cylinders are all steam jacketed and the receivers have heaters, but the second receiver heater was not used during the test. The jacket of the high-pressure cylinder is supplied with steam at boiler pressure; those of the first receiver and intermediate cylinder have steam reduced to 40 lbs., and in the low-pressure cylinder jacket it is reduced to 6 lbs. The condensation from the high-pressure jacket was discharged into the first receiver, and the drip from this receiver was discharged into the low-pressure jacket. The condensation from the intermediate cylinder was discharged into the second receiver, whose drip was taken to the main exhaust pipe. The low-pressure jacket was controlled by a temperature trap set at 198° F., discharging into the hot well. The air, feed and circulating pumps and the air compressor are driven from an arm on the low-pressure plunger.

TEST DUTY. — The guaranteed duty was 160,000,000 ft.-lbs. per 1,000 lbs. of steam used for the first engine, and 165,000,000 ft.-lbs. for the second engine, no deduction being made for steam containing 2% or less of moisture. The work was to be based on the plunger displacement, with no deduction for leakage or slippage less than 1%. To accomplish the higher duty in the second engine, reductions were made in the clearance of the steam cylinders. The 24-hour duty tests were made in March, 1907, and April, 1909, respectively, and the results of the tests are given in Table II. The test of the first engine (No. 5) was made after the engine had been in service about six months. Although the engine was stopped for minor adjustments before the test was made, it was not found advisable to change the valve setting to secure a better steam and load distribution than had existed in the engine when running in regular service. When the second engine (No. 6) was tested, it had been in continuous service for nine months, and the trial conditions differed from those of normal service only in the weighing of the feed-water and the taking of observations at intervals of 15 mins. As engine No. 5 was using steam from the same boilers, no notice of the boiler work was taken in the test of engine No. 6.

STATION DUTY.—A special feature of interest in these engines is the high duty which has been maintained in regular service. Engine No. 5 showed a duty of about 163,236,000 ft.-lbs. for a week in 1907, and 160,097,000 ft.-lbs. for a continuous run of 168 hours in 1908. The following particulars of the station duty performance are taken from a paper (copyright) on "High Duty Pumping Records at the North Point Pumping Station, Milwaukee, Wis.," read by Mr. Cornelius T. Myers* at the annual meeting of the American Water Works Association in April, 1909.

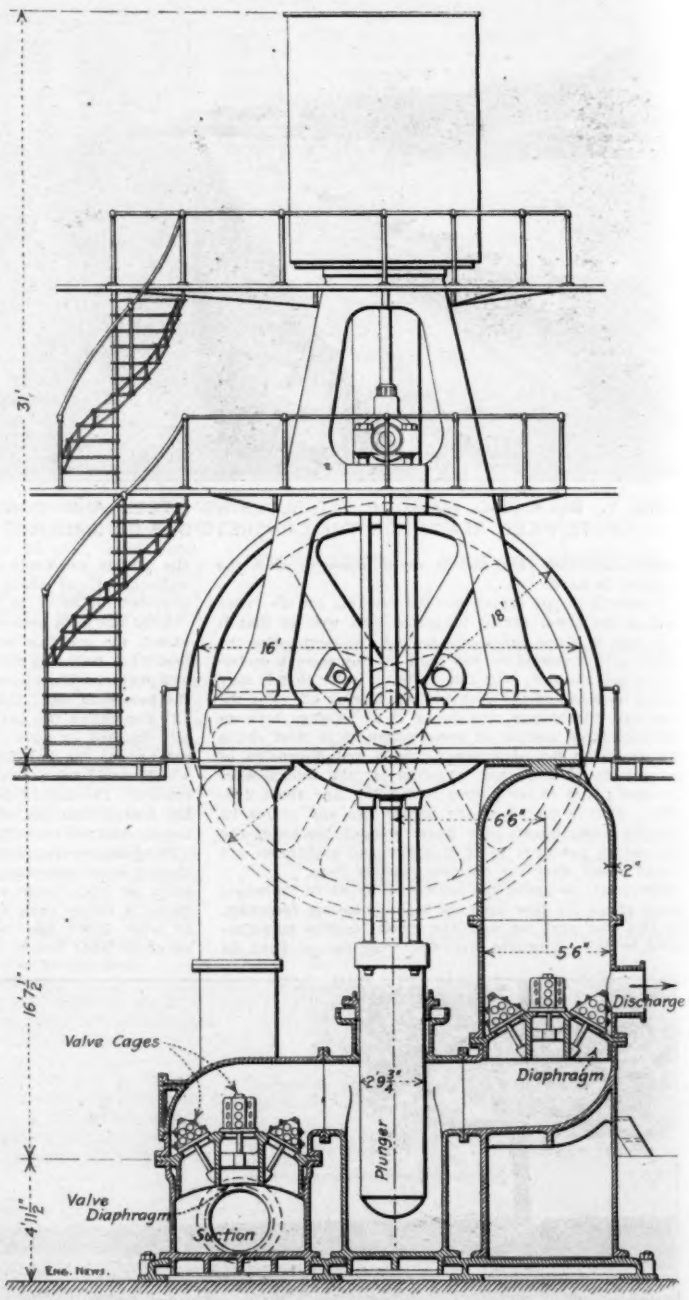


FIG. 1. SECTIONAL END ELEVATION OF 20,000,000-GALLON TRIPLE-EXPANSION PUMPING ENGINE FOR THE MILWAUKEE WATER-WORKS; SHOWING THE ARRANGEMENT OF DIAPHRAGMS AND CAGES FOR THE SUCTION AND DISCHARGE VALVES.
Wisconsin Engine Co., Corliss, Wis., Builder.

At the last analysis station duty is the figure to which we look as the true indication of the value of the high-duty pumping engine. Test duties, while they are of great value because of the complete and detailed data obtained, offering opportunity for engineering analysis and research, are of but secondary importance to the corporations which must operate the engines. The coal bill for the actual services rendered day by day and year after year is the criterion by which the value of these

*Wisconsin Engine Co., Corliss, Wis.

TABLE I.—DUTY TESTS OF PUMPING ENGINES AT ALBANY, N. Y.

	Eng. No. 1	Eng. No. 2.
Date (1909)	May 29-30	June 2-3
Duration of test (hours)	24.083	24
Pressure: Steam at engine throttle, gage, lbs.	153.56	153.02
Barometric, lbs.	14.60	14.67
Steam at engine, absolute, lbs.	168.16	167.69
1st receiver, lbs.	26.00	23.00
2d receiver, lbs.	—3.80	—3.50
Discharge press., gage (corrected), lbs.	135.58	136.42
Equivalent head, ft.	313.118	315.08
Total test head, ft.	322.312	324.40
Equivalent pressure, lbs.	139.561	140.456
Vacuum, ins.	26.375	25.90
Barometer, ins.	29.619	29.76
Temperature (F.): At eng. throttle.	355.70	358.25
In calorimeter	288.29	285.89
Exhaust at condenser	121.00	123.00
Hot well	88.00	88.00
Injection water	65.00	65.00
Water pumped	65.00	65.00
Engine room	81	81.00
Total revolutions during test	31,988	31,687
Feed water, total weighed, lbs.	189,440.00	193,857.5
Feed water corrections:		
Steam separator	856.73	660.0
Boiler leakage	4,380.00	4,365.0
Header drips	2,330.50	2,284.0
Total	7,567.23	7,309.0
Total feed water chargeable to engine	181,872.77	186,548.50
Leakage, plunger, gals. per hour	30.00	30.00
Discharge valve	16.00	12.00
Suction valve	10.80	360.00
Suction gate valve	10.50	.....
Water pumped per 24 hours, gals.	12,193,000	12,120,000
Duty per 1,000 lbs. of steam delivered, ft.-lbs.	180,734,000	175,666,000
Duty per 1,000 lbs. of dry steam, ft.-lbs.	183,115,000	178,106,000

TABLE II.—DUTY TESTS OF PUMPING ENGINES AT MILWAUKEE, WIS.

	Eng. No. 5.	Eng. No. 6.
Date	Mar. 6-7, 07	Apr. 2, 09.
Duration of test, hours	24	24
Total revolutions	29,604	29,434
Ave. revs. per min.	20.558	20.44
Piston speed, ft. per min.	205.58	204.40
Steam press: h.-p. cyl., lbs.	123.20	123.00
Intermediate cyl., lbs.	.....	27.00
Low-press. cyl., lbs.	.....	2.00
1st receiver, lbs.	29.55	.....
2d receiver, lbs.	3.26	.....
Ave. vacuum, by gage, ins.	28.35	27.4
Water press., by gage, ft.	130.370	135.283
Water press., gage above datum, ft.	25.930	25.930
Water in suction conduit below datum, ft.	1.576	1.857
Total average head, ft.	157.876	163.57
Temp. of water pumped	34° F.	37° F.
Wt. of water, lbs. per cu. ft.	62.42	62.42
Displacement of plungers per rev., lbs.	5,815.86	.....
Displacement of plungers per rev., gals.	697.107	697.107
Total water pumped, gals.	20,637,155	20,515,498
Total water received from condensers, lbs.	167,468	167,420
Duty per 1,000 ft.-lbs. of steam, as per spec., ft.-lbs.	162,338,672	167,277,223
Percentage of moisture in steam	1.384	.....
Percentage of dry steam	98.616	.....
Duty per 1,000 ft.-lbs. of dry steam, as per guarantee, ft.-lbs.	164,616,967	170,691,044
Ave. I. HP., high-press. cyl.	176.54	213.127
Intermediate cyl.	180.424	187.607
Low-press. cyl.	257.237	205.311
Total	614.201	606.045
Delivered HP.	572.109	589.342
Friction HP.	42.092	16.704
Total mechanical efficiency	.....	97.24%
Dry steam per I. HP. per hour, lbs.	.....	11.28
Dry steam per deliv. HP. per hour, lbs.	.....	11.599

complicated and costly engines must be measured. There are pumping stations where are installed engines which on test show very remarkable duties, but the station duty as shown by the daily log fails to reveal a relative saving in the coal bill. It is of interest therefore to take from the log of the North Point (Milwaukee) pumping station the data necessary for computing the station duty of engine No. 5.

In the week ending Sept. 14, 1907, 145,200 lbs. of Pocahontas mine-run coal were burned under the south battery of boilers. These are not in as good condition as when Prof. Carpenter made his test 13 years before, the average factor of evaporation now being about 8.25, and the performance of the engine is therefore the more creditable by comparison. The engine ran at an average speed of 20.27 r. p. m. and delivered water at the average rate of 20,347,000 gals. per 24 hrs. The steam generated by these boilers also supplied a vertical high-speed engine, which furnishes light for the station, and a slide-valve engine which furnishes power for the machine shop which is a part of this station.

The average duty of the engine for the week, without deducting for the steam used by the high speed and slide-valve engines was 132,303,000 ft.-lbs. per 100 lbs. of coal, which is equivalent to 160,038,000 ft.-lbs. per 1,000 lbs. of moist steam. If 2% is allowed for the average moisture, the station duty of this engine per 1,000 lbs. of dry steam becomes 163,236,000 ft.-lbs., which is within 0.8% of the test duty. The two small engines take about 2% of the total steam generated, but no credit has been given to the pumping engine for this item, as part of the heat value of this steam is returned to the boilers by raising the temperature of the feed water.

Engine No. 6, a duplicate of No. 5, was first started on June 20, 1908. As an indication of the perfection which has been attained in building and erecting machinery of this type it is worthy of notice that within 30 minutes after steam was first turned on to warm up, the engine was not only started, but took its full load, delivering water to the reservoir. Since that time it has been in regular service, the station log showing runs as high as 168 hrs. per week and pumping rates as high as 22,500,000 gals. per 24 hrs.

For the week ending Aug. 1, 1908, all the water for the city was pumped by engines No. 5 and No. 6, each engine running 168 hours. The station duty, without deducting for the coal chargeable to the high-speed and slide-valve engines, is easily figured from the following data:

Total pumpage	280,528,560 gals.
Average head	168.2 ft.
Steam pressure	125 lbs.
Vacuum on Engine No. 5	27 ins.
Vacuum on Engine No. 6	26½ ins.
Average r. p. m., No. 5	21.13
Average r. p. m., No. 6 (run slow at night)	18.8
Total coal burned	303,900 lbs.

FIG. 2. DIAPHRAGMS AND CAGES FOR THE VALVES OF THE WATER END OF THE MILWAUKEE PUMPING ENGINE.

The station duty over a continuous run of 168 hours by two engines pumping at varying rates (at times 15% above and again 15% below the rated capacity for which they were designed to give maximum efficiency) was 129,490,655 ft.-lbs. per 100 lbs. of coal, without allowing for the coal chargeable to the small engines. The average factor of evaporation of the boilers is about 8.25 lbs. of coal per pound of steam evaporated under working conditions. Taking the entrained moisture as only 2%, the station duty per 1,000 lbs. of dry steam becomes 160,097,000 ft.-lbs. and 11.43 lbs. of dry steam per I. HP.-hr., assuming the average friction of the two engines at but 7½%.

The combined station duty of these two pumping engines, one of which had not been in service 30 full days, is within 2¾ of the duty developed on the trial test of engine No. 5, and within 1½% of the test duty guaranteed by the builders. These are results not approached elsewhere, to my knowledge.

It will be noted also that the vacua were considerably below the vacuum on the test of No. 5. This was due to the high temperature of the condensing water caused by an on-shore wind which drove the warm surface water around the intake cribs, and also to some defective construction in the condenser on engine No. 6. A number of runs made with varying degrees of vacuum show that for an increase in vacuum from 26½ ins. to 28 ins. the duty is augmented by amounts varying between 2,000,000 to 3,500,000 ft.-lbs. per 1,000 lbs. of steam. No credit has been allowed for this, however.

Annual Convention of the Wood Preservers' Association.

The sixth annual meeting was held at the Auditorium Hotel, Chicago, Jan. 18 to 20, with a good attendance. There was a good list of papers, all of which were short, but the discussions were of less interest than at the 1909 meeting when there were no papers and the proceedings consisted of discussions on subjects selected at the opening session. We give below some notes of the principal papers.

EFFECT OF THE TIME OF CUTTING TIMBER.—In this paper, Mr. J. C. Williams (Superintendent of the Wood Preserving Department of the Barber Asphalt Paving Co.) pointed out the time of cutting may affect the rate of seasoning and the preservative treatment. Two factors of the time of cutting which may affect seasoning are (1) the amount of water in the tree and (2) the weather conditions after the cutting.

It is generally supposed that trees contain less water in winter than in summer, and it is a common expression to say that the "sap is down in the winter." This is partly, if not wholly, wrong, as some trees contain as much water in winter as in summer, if not more. The first effect of the time of cutting is that there is more water to be evaporated from fall and winter cut timber than from spring and summer cut timber.

The conclusions we may draw are as follows:

(1) The time of cutting directly affects the rate of seasoning, because at certain seasons the moisture content of the timber is greater than at others, and because for air seasoning the weather is not as favorable at certain times as at others.

(2) The time of cutting does not affect the treatment of air-seasoned timber, except as it affects the date at which the timber is air dry; but it does affect the treatment of artificial seasoned timber, because of the higher moisture content of the wood at certain times.

(3) The effects of the time of cutting (both on the rate of seasoning and the treatment) may be favorable or unfavorable, depending on the time of cutting.

(4) For limited terms of seasoning to permit treatment at the earliest date after cutting, and for treatment with artificial seasoning with the least danger of injury to the timber, spring and summer are the preferred seasons for cutting.

HAULAGE SYSTEMS FOR TREATING PLANTS.—In this paper, Mr. Andrew Gibson (Superintendent of Timber Preservation, Northern Pacific Ry.) described the methods used at the plants at Brainerd, Minn., and Paradise, Mont. A 10-ton 250-volt electric locomotive is used, on a 30-in. gage track, to handle the retort cars in the yard and in the cylinders. The greatest haul is about 3,300 ft., with grade practically level and curves up to 24°. The only trouble is the occasional slipping on sharp curves, and the engine should be 5 tons heavier.

Our retort cars are handled by a cable extending under the cars, supported on hooks from the drawheads to hold the cable off the ground or catching in frogs and switches, and at the car furthest away from the locomotive looped over the ties so that when one car moves all the cars in the train move. If (which is very rare) a car sticks in the cylinder, we drop the end of the cable attached to the train and hook on a short cable, which is always carried on the locomotive, and pull out the cars one by one until the derailed car is reached. When it is removed, we simply pick up the end of the cable extending to the last car and pull out the balance of the train at one operation.

Where different conditions exist, such as short hauls or transfer tables used, a cable and drum might possibly be more economical. But with a haul and other conditions such as we have, I am firmly of the opinion that the electric locomotive is the most suitable and econom-

ical. No locomotive using fuel oil or coal should be used in a tie and timber treating yard. The element of fire risk is too great.

Mr. Angier said that at the Galesburg plant of the Chicago, Burlington & Quincy Ry. a standard gage locomotive is used in the yard, the tracks having three rails. For handling cars in and out of the retort a hoisting engine is used. This was at first operated by steam piped from the boiler house, but is now operated by compressed air distributed through the same pipes, and this is more satisfactory. Another member considered it unsatisfactory to push a train of 16 cars into a cylinder, as liable to cause derailment. It is better to haul them in. The use of gasoline locomotives was suggested.

INFLAMMABILITY OF TREATED TIMBER.—This paper was by Mr. H. M. Rollins (Superintendent of the Texas & New Orleans Wood Preserving Works). He pointed out that as zinc chloride is deliquescent, it tends to render timber fireproof. Creosoted timber is generally regarded as inflammable, but after a certain time it is actually less so than untreated timber. This is due to the fact that the lighted oils, which vaporize freely, have passed off, and the heavier oil remaining is difficult to ignite. When a stick of creosoted timber is ignited it becomes charred on the surface only during a period sufficient for the entire destruction of a stick of untreated timber.

In the discussion reference was made to ties in the track, and it was stated that creosoted ties ignited by burning cinders would suffer less damage and be less liable to extend the fire to other ties than where untreated ties are used. Ties treated with zinc have been found to be considerably damaged in some cases by cinders. Some mines decline to use creosoted timbers on account of the general idea as to their inflammability.

DOORS FOR RETORTS.—Two papers on this subject were presented. Mr. S. M. Rowe (Consulting Engineer) preferred the spider door. Mr. David Allerton (Superintendent of the Kettle River Quarries Co.) gave equal approval to this door and to the door fastened by bolts. The small wheel which supports the door when swinging is generally a nuisance, and he suggested supporting the door from a crane on the cylinder. He also suggested hinging the door at the top, so that it could be raised and lowered by a hoist. One member supports the door, when open, by an overhead chain. Others had found it difficult to get a uniform pressure around the door by the spider fastening, while the spider arms are likely to become bent or displaced.

PRECAUTIONS AGAINST FIRE.—A paper by H. J. Whitmore (Superintendent of the Wood Preserving Works of the Missouri, Kansas & Texas Ry.) described the conditions of the burning of that plant in February, 1909. He suggested the following precautions:

Never allow leaks in oil pipes. Buildings to be of fireproof material. Never allow open lights in, or around the plant. Have the fire pumps in a separate building or have a high tank of sufficient capacity for water pressure. Have plenty of room between buildings, and a system of steam pipes in the pump room to smother out a fire.

A paper by Mr. Lowry Smith (Assistant Superintendent of Tie Treating Plants, Northern Pacific Ry.) gave much the same advice. He recommended further, however, the enclosing of all tanks containing hot oil, the use of a 6-in. water seal in all storage tanks, and the provision of fire-hose and 3-gal. chemical extinguishers in the buildings. The yards should be kept clean, with 20-ft. alleys between the piles of ties and transverse 4-ft. alleys at intervals of three or four piles. A 6-in. or 8-in. water main should be laid, with hydrants 150 ft. to 200 ft. apart. Some of the members described their systems of watching the yards, the watchman having to call periodically at several clock stations, and also to follow freight trains to look out for tramps.

THE WITHDRAWAL OF CREOSOTE OIL FROM WOOD BY VACUUM.—In this paper, Mr. J. B. Card (Chicago Tie & Timber Preserving Co.) questioned the possibility of the results claimed by advocates of the so-called "open cell" process as to the amount of oil recovered by a final vacuum when no initial vacuum is used. He thought that if such results were obtained they would be rather detrimental than otherwise. Some of the members, however, claimed that 60 to 75% of the oil put in could be taken out, leaving the cell walls impregnated. Others doubted this, however, and suggested that the apparent results were due to careless measuring or faulty operating methods, the oil claimed to be withdrawn having never been forced into the timber. These took the view that with proper treatment there was little air left in the treated ties, while the advocates of the open-cell methods claimed that the air was imprisoned, and after being compressed by the pressure in the cylinder, expanded (when the vacuum was created) and forced the oil out of the cells. The discussion began to be somewhat acrimonious and personal, but was stopped by the president. The following is an extract from the paper:

The many experiments I have made in creosoting ties without the initial vacuum, have clearly demonstrated to me that wood does not contain a sufficient amount of air to throw out by expansion more than 10% on an average of the creosote injected. And the greater the amount of creosote injected into a tie against the natural air in the wood, the smaller will be the amount regained by expansion or vacuum, or both.

If the pressure is maintained long enough, the air (being lighter than the oil) will pass out of the wood to a great extent as the oil is being forced in, and when the air is out of the wood, then nothing will be regained by expansion or vacuum.

Our results show that only 10.4% of the oil injected into six different kinds of wood, by the Lowry process, was regained with a final vacuum of 26 ins. for two hours. And 10% was regained when no final vacuum was used, the ties being allowed to drip for two hours. The total per cent. of oil regained from ties at a treating plant does not, by any means, come from the interior of the wood, at least 33⅓% drips from the outside of the ties, the cylinders and tram cars. When this is taken into consideration, the average amount of oil regained in these experiments is 7%.

The amount of creosote oil regained from oak ties by the vacuum process is less than any other kind of wood. The experiments made at the C., B. & Q. Ry. treating plant at Galesburg show an average regain of 7.6% for this class of timber. If allowances are made for the drip from the outside of the ties, etc., this will be reduced to 5%.

AMOUNT OF ANTISEPTICS REQUIRED.—A paper by Mr. R. L. Allardyce (General Superintendent of the International Creosoting & Construction Co.) gave recommendations which we summarize below:

Creosoting.—For marine work, from 22 lbs. per cu. ft. to as much as the wood will take. The lighter treatment for northern waters or where there is no trouble from the teredo or other borer. For land work; 15 to 20 lbs. per round piling; 12 to 15 lbs. for caps, stringers and braces; 18 to 20 lbs. (and not less than 15 lbs.) for decking, especially when used as a base for gravel covering; for telegraph and telephone poles, 12 to 15 lbs.; in ties, 10 lbs. if tie-plates are not used to protect the ties from mechanical wear, but a heavier treatment if they are so protected.

Zinc and Oil.—A zinc-chloride solution of ½-lb. dry salt per cu. ft. of wood (making practically a 4% solution); then an injection of 3 or 4 lbs. of oil to prevent the salt from leaking out.

Zinc-Chloride or Burnettizing.—The same ratio of dry salt per cu. ft. but with ½-lb. of dry salt to 15 lbs. of water. This is considered as economical only in dry districts, as moisture will leak out the salt.

In the discussion, Mr. O. Chanute pointed out that no mention was made of the zinc-tannin process, which is extensively used and gives the ties a life two or three years longer than that due to the straight zinc process (burnettizing). Mr. W. W. Curtis expressed the opinion that a 10-16 treatment with uniform distribution is better than a 14-16 treatment with the material mainly near the surface. In other words, good distribution is more important than the amount of injection. He also advocated specifying a minimum pressure, and approved of the open-cell process, thus starting a rather sharp discussion which has been mentioned above.

THE PROPER GROUPING OF TIMBERS FOR TREATMENT.—Mr. F. J. Angier (Superintendent of Timber Preservation of the Chicago, Burlington & Quincy Ry.) reviewed the discussion on this subject at the 1909 meeting. He stated that as the result of extended experiments his practice is to treat only one kind of wood in a charge, but when it is not possible to do this the timbers are divided into three classes: (A) those absorbing less than 22% in volume, (B) 23 to 30%, (C) more than 30%. These timbers are as tabulated below. His experience has been limited mainly to ties (and a small amount of bridge timber), and to the burnettizing (zinc-chloride) and Card (zinc-creosote) processes, so that practice might be different at other plants under different conditions;

TABLE OF THE GROUPING OF TIMBERS FOR PRESERVATIVE TREATMENT.

Class A.	Class B.	Class C.
Oak (red, pine, white).	Sweet gum...	Short-leaf pine.
Hickory.....	Chestnut.....	Tupelo gum.
Beech.....	Hard maple..	Soft maple.
Hemlock.....	Ash.....	Elm (red, white).
Tamarack.....	Sycamore.....	Cypress (white).
	Poplar.....	Birch (red).
		Cottonwood.

At our Sheridan plant, practically nothing but lodgepole pine, bull pine, and Douglas fir are treated, and these are separated. We find Douglas fir to be very satisfactory, and only aim to treat this wood after it is thoroughly seasoned. When green, it requires considerable steaming.

As to hewed and sawed ties, we make no distinction other than to separate them whenever possible for convenient loading. Each tier of sawed ties is separated on the tram cars with a ¼-in. iron strip, that the solution may have free access to all sides of the tie.

With dimension timber it is, no doubt, best to treat each size by itself, but when this is impracticable, I would classify everything 3 ins. and under together; 4-in. and 6-in. stuff in another class; 8-in. and 10-in. stuff together, and everything above 10 ins. in a class by itself. Of course, these should, in turn, be separated as to the different species of wood, and so far as possible, between sap and heartwood.

It is understood by all that green and seasoned timber should be separated, and allowance for this should be made applicable to the foregoing remarks.

Other papers were on "Creosote Analysis," by Wm. H. M. Newton (Chemist of the Kettle River Quarries Co.), and "Treating Timber with Crude Oil," by Mr. C. M. Taylor (Chemist of the International Creosoting & Construction Co.). Of this latter we shall give an abstract later.

The election of officers resulted as follows: President, Walter Buehler; Vice-Presidents, C. W. Berry, David Allerton and C. D. Chanute; Secretary and Treasurer, F. J. Angier (C., B. & Q. Ry.), Galesburg, Ill. The next meeting will be held at Chicago in January, 1911.

A WATER STERILIZATION PLANT for portions of the city and suburbs of Montreal was put in operation by the Montreal Water & Power Co. on Jan. 18. Bleaching-powder or calcium hypochlorite is used, apparently in accordance with the general plan followed at Boonton, N. J., by the Jersey City Water Supply Co. It is stated that this sterilizing plant will be used until a proposed installation of filters is completed. We understand that arrangements for installing filters had been made prior to the recent outbreak of typhoid fever at Montreal noted in our editorial columns of Jan. 13 and 20. As we stated in the last-named issue, it was reported that a similar sterilization plant would be installed at once by the city of Montreal, but we have not yet heard that this has been done.

COAL MINE ACCIDENTS IN TENNESSEE, OHIO and Illinois in 1909 have been reported by the State mine inspectors as follows:

In Tennessee coal mines, there were 25 fatalities, of which 18, or 66%, were caused by falls of roof. The coal production was 6,234,922 short tons.

In Ohio mines, 114 men were killed as compared with 112 in 1908. Ohio's coal production was 28,107,000 short tons.

In Illinois mines (in the fiscal year ending June 30, 1909), 212 men lost their lives, an increase of 16% over the number of fatalities in 1908. Falls of coal and rock killed 84 men, or 39½% of the total. The coal production was 49,163,710 short tons.

The lives lost per million tons of coal produced were 4.01 in Tennessee, 4.06 in Ohio and 4.31 in Illinois. For the entire United States, the figure for the year 1909 is 3.84. The number of lives lost per million tons of coal produced in Illinois would have been nearly trebled if the period considered had included the Cherry disaster.

Emergency Repairs to a Bascule Drawbridge Over the Chicago River; Chicago Terminal Transfer Ry.

By F. H. AVERY.*

The Chicago Terminal Transfer Ry. crosses the Chicago River at Taylor St. (near the Grand Central Station) by a double-track double-leaf bascule bridge of the Scherzer rolling lift type, having a span of 275 ft. c. to c. of bearings. On Sunday morning, Dec. 6, 1908, the bridge (while closed) was struck a violent blow on the upstream side by the steamer "Eber Ward," and was badly damaged. The blow was delivered against the bottom chord of the truss of the east leaf, close to a panel point (with the floor beam below the chord). As the ship's bow struck at a point where it was reinforced by a deck it was not seriously injured, only a part of the upper works being crushed in against the truss members. One of the anchors caught in the members and after the ship had recovered from the shock the strain on the anchor cable drew the ship back so that it struck a second blow. The general design of the structure, and the great extent of the repair work required, are shown in Fig. 1.

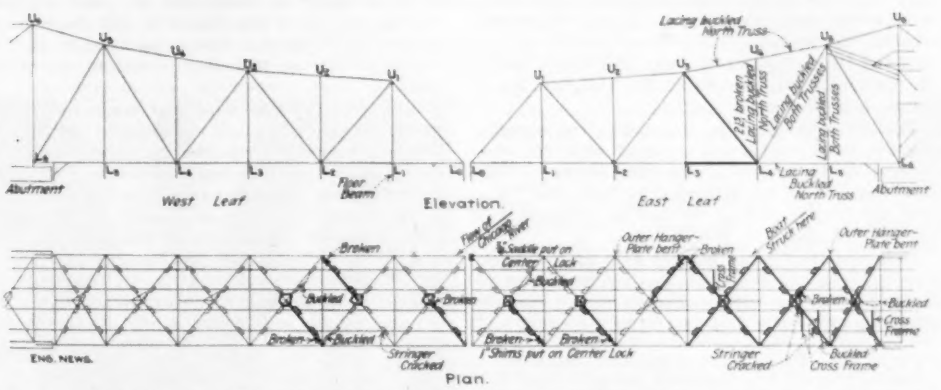


FIG. 1. DIAGRAM OF BASCULE BRIDGE STRUCK BY A STEAMER, SHOWING THE EXTENT OF THE REPAIRS REQUIRED.

FIG. 2. CHORD SECTION KNOCKED OUT OF BRIDGE BY STEAMER.
(Practically the only damage is at the fractured ends).

The damage to the bridge was very serious. The bottom chord section (L-3, L-4), was snapped off like a pipe stem and thrown half way across the floor of the bridge. Fig. 2 shows this piece, which had little or no distortion between the fractured ends. The diagonal (U-3, L-4) was buckled about 3 ft., as shown in Fig. 5. The floor beam connection at (L-4) was torn entirely loose at the jaw plates, allowing the beam to drop about 2 ins. At the first glance this seemed to comprise about all of the damage, but a closer inspection showed a surprising amount of damage to the floor, laterals and lacing of the web members. This consisted of 25 top and bottom laterals broken or buckled, eight stringers broken or bent, and the lacing buckled in nine web members. The entire leaf (which was the one struck by the boat) was buckled about 4 ins. and the center locks jammed tight. It will be seen by Fig. 1 that the damage was not confined to the east leaf. The fact that the bridge was closed at the time of the accident accounts for the breakages in the west leaf.

Being Sunday it was hard to pick up a gang of structural iron workers when the news of the accident reached the engineers. The season for navigation was just closing and a steadily increasing fleet of boats was tying up on each side of the bridge. Passenger trains were not so severely affected, since the three roads using the bridge detoured over the Rock Island Ry. by a connection just east of the bridge. The three roads are the Baltimore & Ohio, the Chicago Great Western and the Pere Marquette Ry.

The first thing to do was to open the bridge for boats, since the trains were not forced to use the bridge. To do this meant to close the break in the bottom chord, brace the diagonal, and chain up the floor beam so as to take the thrust of the braces running to the diagonal. This was done in about 24 hours working time, or from 9 p. m. Sunday to 9 p. m. Monday. The span was not raised, however, until 9 a. m. Tuesday, since it was considered too risky to raise it during the darkness and to take chances on everything working right.

Railway traffic, however, was turned back upon the bridge on Monday afternoon, and maintained throughout the entire time taken to perform the repairs. Only one track was in use. Owing to the weakened condition of the span and the fact that one floor beam was held up by chains, the heavy road engines were taken off the passenger trains and these trains pulled in and out of the station by switching engines. As soon as possible the road engines were taken across, to avoid the time lost in changing engines, but this did not occur until about two weeks.

When a heavy engine would pass over the span, it invariably loosened up the wedges used in closing the chord gap, and it was necessary to drive these up after each train passed. Maintaining this traffic slowed up the work of repairs to a greater extent than would at first be imagined, as very often a heat (for straightening deformed parts) could not be made until after train time, and then the train would be late.

The bottom chord was closed with six timbers 8 × 16 ins., 32 ft. long, arranged as shown in Fig. 4. The four pieces at (A) carried the load; the piece (B) was used to jack against, so as to restore the original panel length, and the piece (C) merely to steady (B). The 32-ft. stringers did not give enough lap past the panel points to get in the necessary number of bolts, and this was remedied by adding the timbers shown at (D). About 20 ⅞-in. bolts were placed in these end timbers, and then wedges driven in between the pieces (A) and (D).

The diagonal was stiffened on the outside with two 8 × 16-in. timbers 32 ft. long, yoked over the member with 1¼-in. rods, and jacks and

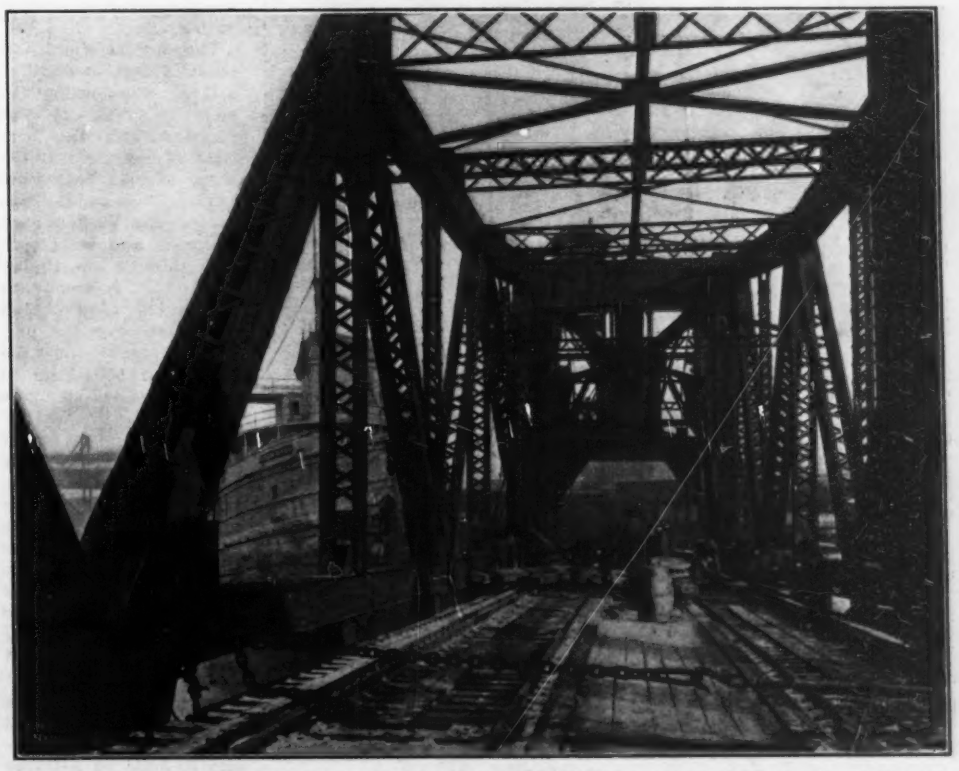


FIG. 3. PULLING THE TRUSSES INTO LINE BY A CHAIN AND RATCHETS. (THIS RELEASED THE CENTER LOCK, WHICH HAD BEEN JAMMED).

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braces on the inside. The 8 × 16-in. pieces were landed on the chord timbers and shouldered against the blocking (E). They were made adjustable by wedges at the top, and the blocking on the inside was provided with wedges. Fig. 6 shows this timbering in place.

The chaining up of the floor beam was a simple matter. The chains were passed over the connection of the diagonals and posts above the bottom chord, and drawn tight by ratchets. The two leaves were pulled in line by a chain and ratchet, as shown in Fig. 3.

As a practical point in this part of the work, it may be noted that the spacing in the chord timbers was obtained in a snowy winter night by clamping the timbers tightly to the chord and marking through the rivet holes by means of red hot bolts. The timbers, when bored, fitted the rivet holes with greater accuracy than was expected. Rivets were "busted out" of the bottom chord, and the ⅞-in. bolts holding the chord timbers were passed through the holes thus obtained (Fig. 6).

To explain why so much blocking was needed it is necessary to state that the east leaf was resting heavily on the west leaf, and the counterweight of the broken east truss hanging hard in the heel lock, so that the conditions (as far as stresses were concerned) would differ greatly when the attempt was made to raise the bridge. The compression in the bottom chord was passing through the stringers into the end floor beam at the abutment and springing this beam so as to jam it into the abutment.

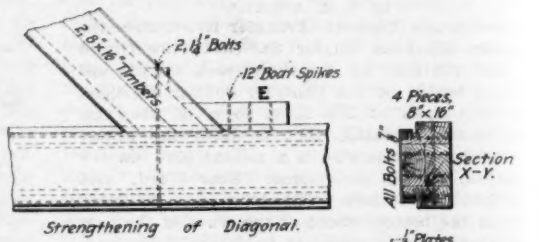
By means of the jacks and wedges in the chord timbers, and the wedges in the diagonal timbers, the panel was pushed back to length. This released the load on the west span, as was easily determined by tapping the center lock jaws with a hammer; it freed the end floor beam from the bank, and released the heel lock.

The bridge was then ready to raise and did rise without any trouble. It was left open four hours to avoid the risk of something happening in closing that would prevent its being opened again, the four hours' time giving all the fleet a chance to move past the bridge. The bridge closed as nicely as it opened, no jamming or interference taking place.

As a precaution against dropping the injured span into the river, piling was driven under the panel points at (L-3) and (L-4). These piles were capped and then blocking placed on the caps so as to clear the floor beam about ½-in. It was not necessary at any time to rest on this blocking, and, so far as using it during the repairs is concerned, it could have been omitted entirely.

The bottom chord was renewed first, one-half at a time. The blocking (B) and (C) (Fig. 4) was removed and the bent ends of the chord at (F) were pushed back into line. The metal was heated and pushed back by jacks and bolts running through the timber (A). The broken ends of the chord were then cut square and the new piece inserted on the inside and bolted up to two 8 × 16-in. stringers 32 ft. long.

The entire inside half of the diagonal was next removed and the inside gusset plate at (L-4) shoved into line. This took considerable time (about a week), as not more than a couple of inches was gained at each heat. The shoving was done by jacks placed in line with the short struts shown in Fig. 6, and to take the thrust of the jacks it was necessary to build an A-frame reaching to the bank and blocked against the truss. Waste soaked in kerosene was stuffed into the diagonal and a wood fire started at the panel point. When the metal was too hot to touch, the fire was pulled out and the jacks and bolts started. The lacing was knocked off the diagonal, as it was found impossible to push the entire member into line. As soon as the inside of the diagonal and gusset plate were in line, the new inside piece was placed.



Strengthening of Diagonal.

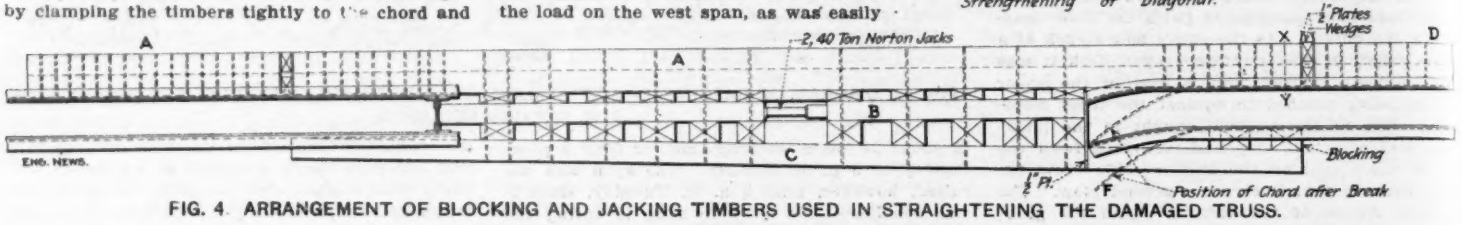


FIG. 4. ARRANGEMENT OF BLOCKING AND JACKING TIMBERS USED IN STRAIGHTENING THE DAMAGED TRUSS.

Splice plates were added at (L-3) and (L-4) of the bottom chord, and the new steel forming the inside of the injured chord and diagonal were stiffened each with two pieces of 8 × 16-in. timber bolted to the member. All of the blocking on the outside of the truss was now removed, and the outside piece of the injured diagonal taken off.

It was decidedly harder to straighten the outside gusset plates at the top and bottom of the diagonal, as there was no chance to use jacks on them. Pushing jacks were made from the 1¼-in. bolts by cutting them to length, sharpening one end and using a nut jammed against a short piece of 1½-in. pipe. The bolt was turned by means of a second nut near the sharpened end. This nut was set up to the bolt by pounding it when hot. This device was of great service, as it could be made any length, for as the plate moved out the piece of gas pipe was lengthened. The end of the bolt was sharpened to keep it in position when the bolt was turned.

When the outside gusset plates were straight and in line, the outside pieces of the chord and diagonal were placed and laced to the inside pieces. All timbering was now removed and the floor beam secured by new jaw plates. The work from this point on was plain sailing.

Since the bridge had to be operated during the repairs, the A-frame on the dock was partly replaced by chains and ratchets underneath the floor, which acted as tension diagonals. Since the strain on the jacks and struts had to be maintained till the metal had cooled, considerable time would elapse after a heat had been secured, and, if it was necessary to raise during the time this took, the chains under the floor were utilized to take the thrust of the jacks. This thrust was considerable and without the A-frame would push the opposite truss out each time the jacks were worked, as the broken bottom laterals offered no resistance to the thrust.

Considerable trouble was caused by the ⅞-in. bolts used in drawing the gusset plates, breaking upon cooling. This was stopped by driving a drift pin through a hot nut so as to enlarge the hole and then hammering several nuts on the bolt next to the head. About 100 of these bolts were used in the outside bottom gusset plate.

Another practical point in the straightening of the broken ends of the bottom chord at (L-4) was to cut a "V" in the outstanding leg of the angles, the "V" closing up as the angle straightened. In fact it was found almost impossible to straighten without this cut. Where the bend was the opposite way a cut was made with a hack saw, thus leaving a V-shaped opening when the angle was straight. None of this showed in the finished work, as it was covered by the splices on the angles.

The bottom laterals were replaced on one track at a time without interrupting train service.

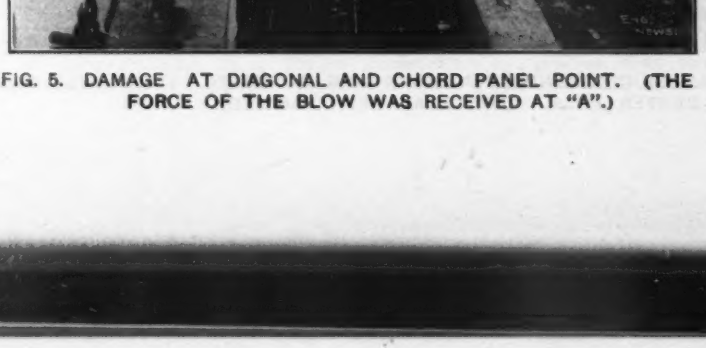


FIG. 5. DAMAGE AT DIAGONAL AND CHORD PANEL POINT. (THE FORCE OF THE BLOW WAS RECEIVED AT "A".)

They were made heavier than before to take care of the 4-in. buckle that was to be left in the truss. The laterals were left blank at one end and field drilled to match the lateral plates.

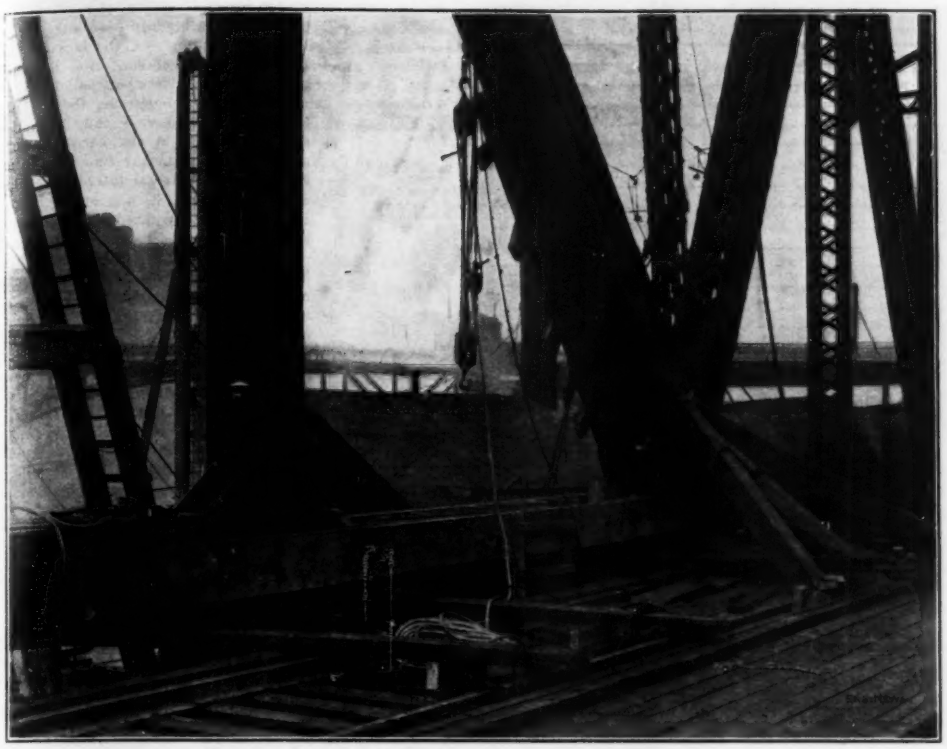


FIG. 6. TEMPORARY REPAIRS COMPLETED AND BRIDGE READY TO BE RAISED.

(The long timbers form the chord section to replace the section knocked out by the steamer. The timber bolted to the diagonal was replaced by one extending to the top of the diagonal).

Buck frames were placed at each point where the stringers were bent or broken.

Considerable experience was gained during the course of the work as to the best method to tackle different parts of it. For one thing it was found much better to heat with charcoal, as it did not drive the men away with smoke or flame, gave a much steadier heat than a wood fire, and could easily be moved or taken out. Also, it paid to let the metal cool off entirely after a heat, keeping the bolts up as tight as possible, for if any changes were made while the metal was warm it would at once jump back as much as was gained during the heat. Large canvas paulins were hung up on each side of the injured portion of the truss to keep the snow and sleet off and afford protection from the prolonged cold winds, and this kept the men at work days when it would have been impossible to work without this protection.

A few words may be added about the steamer that caused all the trouble. It was an old wooden boat about 200 ft. long and was proceeding to the dock to tie up for the winter. Oddly enough on the first trip out next season, loaded with corn, it struck an ice floe and sank in deep water with five of the crew.

This article is not written to show any peculiar or unusual methods taken in repairing such a serious break, but for the benefit of the engineer who (without any previous experience with such a break) may be suddenly called upon to patch it up temporarily so that the bridge may be raised with the least possible loss of time. Plenty of advice is given (by those qualified and otherwise), illustrating about 40 different ways in which the job may be done. But the man in the field has to decide on something and carry it straight through to completion with no loss of time due to changing his plans, and no time is allowed to prepare elaborate drawings showing how the job should be done.

In this case nothing outside of simple wooden stringers and such bolts as could readily be picked up were used for the temporary repairs, and the writer gives this description of the work in the hope that some engineer unexpectedly going up against the same proposition may remember some of the schemes that were used in this case as a "first aid to the injured."

Mr. E. N. Layfield, M. Am. Soc. C. E., is Chief Engineer of the Chicago Terminal Transfer Ry. The writer is Assistant Engineer and had charge of the design and execution of the repair work above described.

A PIPE TUNNEL SYSTEM for the City of Mexico is being constructed under the direction of Mr. Fernando Arechavaleta, assisted by Messrs. Manuel Jiminez Cincta, Emilio Subiaga and Joaquin Rivera. The inside dimensions of the subway, or gallery, are 280 cm. in width by 185 cm. in height (about 9.2 x 6.1 ft.). Reinforced-concrete blocks are being used in construction. The side walls are 6 ins. thick, the floor 10 ins. and the roof 8 ins. The subway will accommodate a 4-ft. water pipe, besides electric light, power, telegraph and telephone conduits.

THE EDISON STORAGE BATTERY.—When Mr. T. A. Edison brought out his nickel-iron type of storage cell, in 1901 (see Engineering News, 1901, Jan.-June, pp. 385, 416), and showed its large storage capacity per pound of weight and its capability of withstanding general abuse, it was hailed as a marvel. There was no little surprise, therefore, when it was withdrawn from the market a little later that "changes in mechanical design might be perfected."

The new cell is now being placed on the market by the Edison Storage Battery Co., of Orange, N. J. The outward appearance is unchanged and the changes are largely confined to the positive (nickel-oxide) electrode. The former plate frame formed flat pockets, in which a mixture of nickel oxide and graphite was packed. It was found that the plate could not resist the expansion of the nickel oxide. In the new positive plate small tubes of perforated steel, 4 ins. long by about 5/16-in. in diameter and nickel plated, are packed with a mixture of nickel oxide and flake nickel. Each plate is a nickel-plated steel frame holding 30 of these tubes. The negative plates, as before, are essentially a series of flat pockets in which iron oxide is pressed. The methods of preparing the oxide and filling the negative plates have been improved.

The electrolyte consists of a 21% solution of potassium hydrate containing a slight amount of lithium hydrate. The jar is of steel and is designed so that gases may escape but the liquid is held against spilling or escaping with the gases as spray. Evaporation is supplied by replenishing with distilled water. The electrolyte needs complete renewal about every ten months. The data for the two sizes now available are as follows:

	Type A-4.	Type A-6.
Rated output, ampere-hour	150	225
Average discharge voltage	1.2	1.2
Normal rates of charge and discharge in amperes	30	45
Weights complete, lbs.	13.5	19.2
Watt-hrs. per lb.	13.4	14.1
Width of can, ins.	$2^9/_{16}$	3¾
Breadth of can, ins.	5	5
Height of can, ins.	13⅝	12⅜
Required height of battery compartments, ins.	15	15

By testing under severe conditions it was found that with a discharge rate of three times the normal, the pressure dropped 0.03 volt for each 10-amp. increase of current. The watt-hour efficiency ranges from 60 to 65%.

Tests made with a five-ton, 26-ft., street car equipped with the new type of Edison storage cells excited much interest in the newspapers recently. It is claimed that the car operated at a cost of 1 ct. per car mile, and had a distance capacity of 150 miles. Depreciation is said to be reduced from the 80% of ordinary storage-battery cars to about 15%.

FIG. 7. DAMAGED BASCULE BRIDGE WITH TEMPORARY TIMBER CHORD SECTION AND TIMBERED DIAGONAL.

(The piling was not used in the repair work.)

Strengthening Track for Higher Train Speeds.*

By M. L. BYERS,† M. Am. Soc. C. E.

The problem of strengthening track with a view to increasing the speed of trains differs from that of strengthening solely for the purpose of permitting the use of heavier loading, in two ways:

1. Increased speed means increased impact stresses in addition to any increase in stresses due to the use of heavier locomotives required to develop the increased speed.

2. As the speed increases, the ill effect of imperfections in track and equipment increases, and a smaller variation from perfect adjustment is allowable.

The maximum speed of trains has during the past twenty years increased from about 60 mi. per hr. to over 90 mi. per hr., although there has been no such increase in the average speed between stations.

NO FURTHER LOAD INCREASE.—The increase in weight of locomotives, in America since the beginning of railway construction is shown by Fig. 1, while Fig. 2 shows the changes in equipment that have occurred on one of the large railway systems in the past 20 yrs.

For a time, the increase in the size of the locomotive was checked by the difficulty in securing sufficient heat from the narrow firebox to meet steam generating requirements, the firebox being limited in length by the ability of the fireman to evenly distribute the fuel and in width by the space between wheels. This latter limitation was removed by raising the firebox above the wheels, upon which change in design a rapid increase in the size of the locomotive began. Recently, the height and width of the boiler have commenced to limit further increase, due to encroachment on the available tunnel and road clearance dimensions. This condition has, of late years, been met by the more extended use of the Mallet type of locomotive with two independent sets of drivers and cylinders. The effect of this last departure in design has been to secure a larger and more powerful locomotive, without adding to the existing maximum axle load and, consequently, without adding to stresses in track or bridges.

It would seem therefore, that, until some new and radical departure in locomotive design is made, existing maximum axle loads will not soon be greatly exceeded.

INSTABILITY OF RAILWAY TRACK.—While the railway bridge is designed to be a stable structure not subject to permanent deformation, railway track as usually built, on the other hand, is necessarily an unstable structure requiring the more or less constant application of labor to readjust deformation to the point where the deformation remaining is within the allowable limit. The prime cause of this peculiarity of track design is the great cost of construction of a stable structure.

In order to avoid this cost, the tie is carried on a ballast, the particles of which are somewhat free to move under the rolling load or to be displaced by the action of rain or frost; the ballast rests on a subgrade which, for some distance below the plane of contact, is also affected by frost and moisture, whereas a bridge pier or abutment foundation is carried deep enough to be beyond the reach of such action. Moreover, in a very large percentage of the cases, the unit carrying power of the subgrade is so low that it is often overloaded by the passing train, deformation being the result.

MEANS OF STRENGTHENING TRACK.—The relative carrying power of the various subgrades naturally divides into two classes the problem of the strengthening of the roadway, namely:

A. Where the carrying power of the roadway is, at all times, sufficient to sustain, direct from the tie, the moving load. In this case, only such amount of ballast under the tie is required as will be sufficient for the correction of the inequalities in the surface of the subgrade, and the direction in which the strengthening of the track must be secured lies in the use of a stronger and stiffer rail, or in the placing of the rail supports (the ties) closer together, or both.

B. Where the carrying power of the subgrade is small. In this case, the principal factor in the problem of the strengthening of the roadway is how to increase the stability of the subgrade. There are two ways to accomplish this: (a) by increasing the unit carrying power of the subgrade; and (b) by reducing the maximum unit pressure on the subgrade.

The carrying power of the subgrade can be increased by drainage, or by substituting more suitable material, the latter being usually too costly to be permissible.

Reduction of the maximum unit-pressure on the subgrade can be accomplished by increasing the uniformity of distribution of the load, and by increasing the area of the subgrade over which this distributed load is applied. This can be accomplished by: (1) Increasing the depth of the ballast; (2) increasing the length, width and number of the ties; and (3) increasing the stiffness of the rail. And, of course, in extreme cases, by combining two or more of these means.

The effect of strengthening the subgrade and reducing the maximum unit pressure thereon is to decrease the rate of deformation; the alternative is to increase the amount of labor applied to correcting the deformation, with a view to keeping at all times within the permissible limit.

As the speed of the trains is increased, bringing with it a consequent increase in the size of the locomotive required to produce this increased speed, it becomes necessary to adopt a greater number of these means of keeping the track deformation at all times within the allowable limit, and it must be kept in mind that the allowable limit decreases with the increase in the speed of the train. Finally a point will be reached where, with the present type of track construction, it will be impossible to keep track deformation within the limit permissible for the speed desired, or, at least, to accomplish this at a cost less than that incident to the adoption of a stable type of roadway construction.

In keeping track deformation within the allowable limits, as has already been suggested, the use of stiffer rail, the increase in the size and number of ties, the increase in the depth of ballast, the drainage of the subgrade, the use of better materials therein, and the application of labor to the correction of deformation, are means which are to a greater or less extent interchangeable and, where the full use of all these means is not required in order to secure the results sought, it becomes a problem in railway economics to determine by which of the various means the results can most cheaply be secured. Unfortunately, so many indeterminate factors enter into this problem that its exact solution is impossible, and the most that can be accomplished is to determine from theoretical discussion, and from practical experiments and observation, the general results which may be expected to follow modifications of existing practice in these various directions.

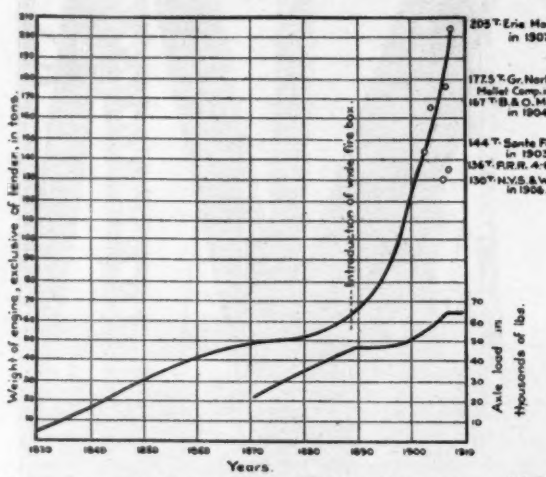

205 T. Erie Mallet Comp. in 1907.
172.5 T. Gr. Northern Mallet Comp. in 1906.
167 T. B. & O. Mallet Comp. in 1904.
144 T. Santa Fe 2-10-2 in 1903.
134 T. P.R.R. 4-6-2 in 1903.
130 T. N.Y.S. & W. 2-8-0 in 1906.
Introduction of wide fire box.
Weight of engine, exclusive of tender, in tons.
Axle load in thousands of lbs.
Years.

Fig. 1. Increase in Locomotive Weight Since Beginning of Railways.

THE TRACK AND ITS LOAD.—What may be termed the American standard high-speed track of today, may be described briefly as follows: Rail, 85 to 100 lbs. per yd.; ties, 6 × 8 ins. × 8 ft., or 7 × 9 ins. × 8 ft. 6 ins., spaced 18 per 30-ft. rail; ballast, 12 ins. under tie; subgrade, 18 to 20 ft. wide on single track, with 13 ft. between centers where additional tracks are used.

Probably the severest load per foot of track from any American rolling equipment of today is that produced by the driving wheels of the Pacific type passenger locomotive of the Pennsylvania R. R. with its three pairs of driving wheels having a load of 61,300 lbs. per axle on a total driving-wheel base of 13 ft. 10 ins. Considera-

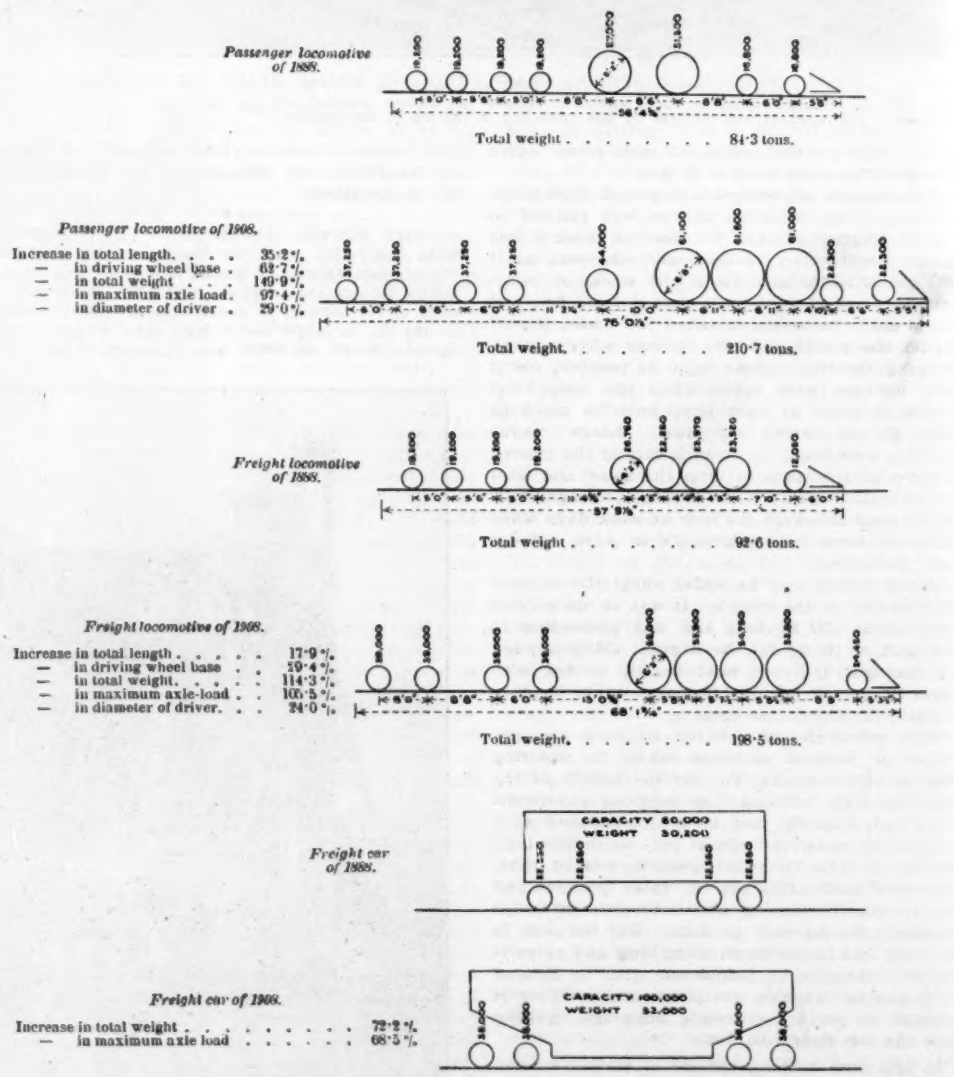

Passenger locomotive of 1888.
Total weight . . . . . 84·3 tons.
Passenger locomotive of 1908.
Increase in total length. . . . 35·2 %.
— in driving wheel base . 62·7 %.
— in total weight . . . 149·9 %.
— in maximum axle load. 97·4 %.
— in diameter of driver . 29·0 %.
Total weight. . . . . 210·7 tons.
Freight locomotive of 1888.
Total weight . . . . . 92·6 tons.
Freight locomotive of 1908.
Increase in total length . . . . 17·9 %.
— in driving wheel base . . 59·4 %.
— in total weight. . . . . 114·3 %.
— in maximum axle-load . . 105·5 %.
— in diameter of driver. . . 24·0 %.
Total weight. . . . . 198·5 tons.
Freight car of 1888.
CAPACITY 60,000
WEIGHT 30,200
Freight car of 1908.
Increase in total weight . . . . . 72·2 %.
— in maximum axle load . . . . . 68·5 %.
CAPACITY 100,000
WEIGHT 32,000

FIG. 2. TWENTY YEARS' INCREASE IN WHEEL-LOADS ON ONE RAILWAY.

*Abstract of a paper published in "Bulletin of the International Railway Congress Association," for September, 1909.

†Chief Engineer of Maintenance of Way, Missouri Pacific Ry., St. Louis, Mo.

tion of the application of such a load to the roadway will make plain that the arrangement of ballast, tie and rail which will permit of the maximum wheel-load being supported by the subgrade is that in which it is possible to distribute uniformly the load from the center driver and half the load of each of the end drivers over that portion of the subgrade covered by this wheel-base. In order to accomplish this result, the ballast must uniformly distribute to the subgrade the pressure from each tie, and the rail must distribute to each tie an equal portion of the wheel-load; this equal distribution of wheel-load by the rail can only be accomplished by the various ties settling into the ballast a sufficient amount to enable the stiffness of the rail to transmit to the adjoining ties their proportions of the total wheel-load, this producing a rail flexure as shown by Fig. 3. The amount of this maximum flexure for different weights of rail, for a distance of 80 ins. between axles, and for different axle loads is shown in Table I.

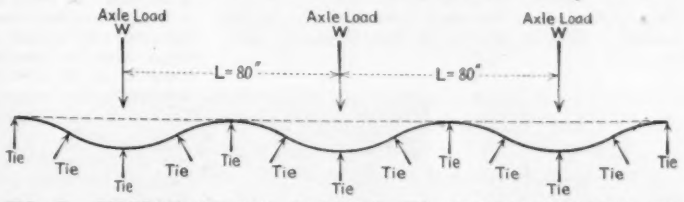


FIG. 3. DIAGRAM OF RAIL FLEXURE TO SECURE UNIFORM TIE LOADING.

It is evident that only in the extreme case of the roadway being loaded to its absolute limit would this perfect distribution of wheel-load to ties be secured. Generally, the tie being able to sustain more than its proportionate part of the load, the rail would not be called upon to perform its extreme service, and the closer the tie spacing the less the bending moment to which the rail would be subjected, this varying directly with the tie spacing.

On the assumption that each tie carries an equal load, the maximum deflection is independent of the tie spacing, and is dependent upon the distance between axles, the axle load, and the stiffness of the rail; consequently, the closer spacing of ties does not permit of reducing the stiffness of the rail; this closer spacing, however, produces in practice a more uniform distribution of the loading over the subgrade and consequently increases the total axle load which the subgrade will carry. The same result is accomplished by increasing the depth of the ballast.

INFLUENCE OF RAIL STIFFNESS.—When the tie spacing and depth of ballast have been so arranged that the distribution of the pressure from the wheel-load is uniform over the subgrade, and the wheel load is of such intensity that the subgrade is loaded to its carrying capacity, then no further advantage can be obtained by increasing the depth of the ballast or by decreasing the tie spacing and the only additional advantage gained by increasing the stiffness of the rail is that the total deflection is thereby reduced; experiments have shown that the smaller this total deflection, the longer will be the life of the rail and the less will be the trackwork required to keep track distortion within the allowable limits.

The relation between the cost of this increased stiffness and the saving in rail wear and in track labor is obscured by so many other factors, that its satisfactory statement is practically impossible, among these obscuring factors being the following: Density of traffic, and consequent rate of rail wear; Intensity of loading; Climate; Character and condition of subgrade; Depth and character of ballast; Size and spacing of ties; Cost and efficiency of labor vs. unit cost of materials; Methods used.

Where the subgrade is of ample strength to sustain the direct pressure from the tie, the principal province of the tie is to support the rail at such intervals as to reduce the deflection and maximum unit-stresses of the latter to within allowable limits, remembering that the less deflection that less will be the rate of rail wear.

The rail deflection and stresses are dependent on both the weight of the rail and on the tie spacing; the heavier the rail and the closer the tie spacing, the less the deflection and stresses from any given load.

Let us assume that the wheel comes directly over a tie which, owing to various causes, offers no support; then the rail must act as a girder with a span of twice the tie spacing. Table II gives the maximum fiber stresses, etc., for various rail sections, tie spacings and axle loads on the above assumption:

For Bessemer steel rail, the allowable maximum unit-stress should probably not exceed 21,000 lbs. per sq. in.

An examination of the table indicates the results which may be expected from varying the weight of rail or the tie spacing.

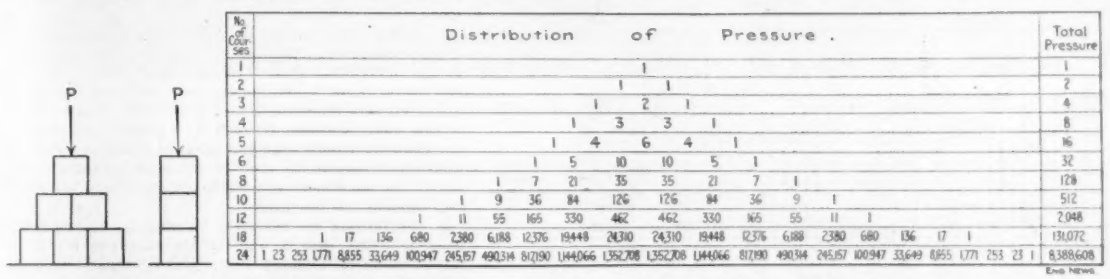


FIG. 4. DISTRIBUTION OF PRESSURE THROUGH A TRIANGULAR STACK OF CUBES.

TABLE I.—RAIL FLEXURE FOR VARIOUS AXLE LOADS AND RAIL SECTIONS.

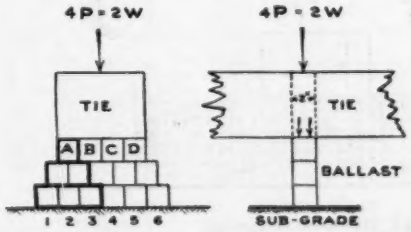
Rail section. Moment of inertia.	Lbs. per yd.	Tie spacing c. to c. in ins.	Deflection in inches. from 60,000-lb. axle load.	Deflection in inches. from 80,000-lb. axle load.	Axle-load W to produce. D = 0.041 in.	Axle-load W to produce. D = 0.031 in.
22.9	75	20	0.059	0.078	42,000	31,500
26.2	80	20	0.051	0.068	48,000	36,000
30.0	85	20	0.044	0.059	56,000	42,000
34.0	90	20	0.039	0.052	63,000	47,000
43.8	100	20	0.031	0.041	80,000	60,000
59.0	110	20	0.022	0.030	109,000	82,000
69.2	120	20	0.020	0.026	126,000	95,000

Effect of Depth of Ballast and Tie Spacing

For the purpose of arriving at an idea of the action of ballast and tie spacing in distributing over the subgrade the pressure of the rail on the tie, the following discussion may be of more or less value:

Assume that the ballast is composed of cubes of uniform size. Consider a pyramid of these cubes, one cube in depth, arranged as per Fig. 4, the top cube sustaining from above a pressure P; it is, of course, possible to compute the portion of P transmitted to each cube in the pyramid; this distribution of pressure for from 1 to 24 tiers in depth is shown numerically by the table in Fig. 4.

As an example, suppose we have 6 ins. of ballast composed of 2-in. cubes; this will require three tiers of cubes, and the table shows the distribution of pressure to the bottom tier of cubes to be as follows: 1, 2, 1, = total 4; in other words, of the pressure P on the top of the cube, one fourth is transmitted to each outside cube and two fourths to the inside cube of the bottom tier which is composed of three cubes, and the pressure is confined to a width at the base of 2 x 3 ins. = 6 ins. Of course this is the pressure from the tie on but one cube of ballast. If we assume the tie to be 8 ins. wide, then there would be 8 ÷ 2 = 4 cubes of ballast to receive the pressure from that particular cross-section of tie, and the total ballast arrangement transferring the pressure from that section to the subgrade would be as shown by Fig. 5, in which W represents the pressure from a cross-section of the tie 1-in. in length.



The pressure from cube A would be transmitted through the pyramid of shaded cubes to cubes 1, 2 and 3, and thence to the subgrade; the pressure from cube B would likewise be transmitted to the subgrade by cubes 2, 3 and 4; that from cube C by cubes 3, 4 and 5, and that from cube D by cubes 4, 5 and 6.

In order to obtain the total pressure on the subgrade resulting from the tie pressure on cubes A plus B plus C plus D, we must combine the individual pressures as follows:

From cube A	1	2	1			
From cube B		1	2	1		
From cube C			1	2	1	
From cube D				1	2	1
Total	1	3	4	4	3	1 = 16
Nos.	1	2	3	4	5	6

Consequently, the entire pressure from the considered section of the tie is carried to the subgrade as shown graphically by the diagram at the right in Fig. 5.

Fig. 6 shows in the same manner the change of pressure distribution secured by increasing the depth of ballast, by changing the size of the cubes of stone, and by reducing the tie spacing.

The distribution of pressure is actually, in some cases, over a wider area than that shown by the diagram, in which pressures per square inch less than ¼% have been neglected.

From these diagrams, the conclusion can at once be drawn that the maximum pressure on the subgrade can be decreased by increasing the depth of the ballast and by increasing the size of the cubes, that is, by using coarser ballast. It is disappointing to note, however, the relation between depth of ballast and maximum unit pressure on the subgrade:

For 6 ins. of 2-in. ballast, maximum unit pressure, 12½% W.

For 48 ins. of 2-in. ballast, maximum unit pressure, 7½% W.

In other words, by increasing the depth of ballast 700%, a reduction of but 40% in the maximum unit-pressure on the subgrade has been secured or, as a result of increasing the depth of ballast 700%,* the load on the tie can be increased but 67% without increasing the unit-pressure on the subgrade.

It will be noted also that the maximum unit-pressure on the subgrade with 12 ins. of ballast and 20-in. tie-spacing (diagram C, Fig. 6) is 12% of W, whereas the minimum is zero, there being a space of 2 ins. at the center between ties over which no pressure from the rail and tie is distributed, the entire pressure from the tie being distributed over an area but 18 ins. in width and 88% of the pressure being confined to an area but 10 ins. in width. This arrangement of ballast and ties, however, may fairly be said to represent standard American practice on high-speed lines, and it will be apparent at a glance how little of the full supporting power of a yielding subgrade is utilized by this arrangement. Fig. 7, a photograph of a section of track on a clay subgrade, shows very clearly the action of the subgrade under a loading so entirely lacking in uniformity. It will be noted that the material of the subgrade has forced itself up through the ballast between the ties, permitting the ballast to sink out of place and, consequently, causing serious track distortion which must be corrected by the application of labor and additional ballast. This corresponds with the results of the experiments and observations of Railroad Director Schubert of Germany as set forth in his lecture before the Verein für Eisenbahnkunde at Berlin in 1899.

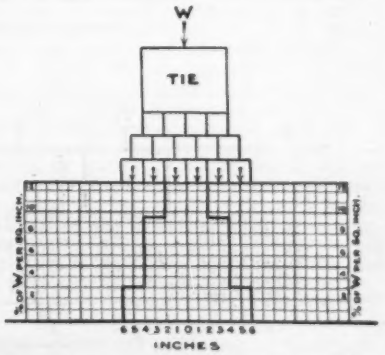


FIG. 5. PRESSURE DISTRIBUTION BY THREE TIERS OF CUBES, LOAD OF TIE UNIFORMLY DISTRIBUTED OVER FOUR CUBES IN UPPER TIER.

*The amount of ballast is increased more than 700%, on account of the side slopes.

With 48 ins. of ballast, under the bottom of the tie but still adhering to the 20-in. tie spacing (diagram D, Fig. 6), it will be noted that the distribution of pressure is much more uniform than with the 12-in. depth of ballast but that it is still far from uniform, varying from a maximum of 7½% W. to a minimum of 3% W, so that it is merely a question of intensity of loading and condition of subgrade to produce conditions such as shown by Fig. 7.

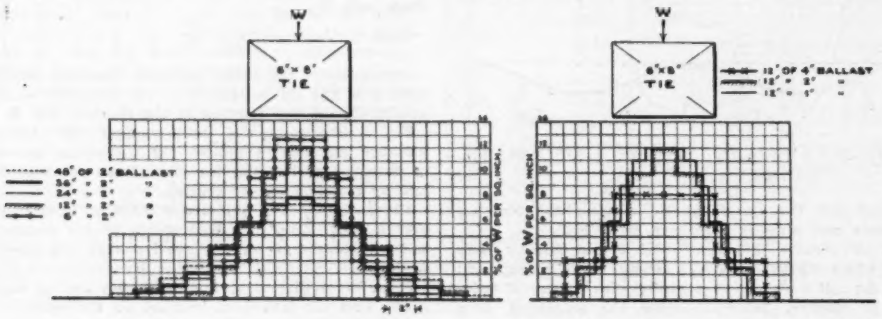
With tie-spacing reduced to 10 ins. between centers, (assuming that each tie will be required to transmit to the ballast but one-half the pressure transmitted by each tie where the spacing is 20 ins.), it will be found from diagram E, Fig. 6, that the maximum pressure per square inch has been reduced to 6% of *W* (*W* being the pressure transmitted by the tie with 20-in. spacing). This would increase the number of ties 150% and would reduce the maximum pressure per square inch on the subgrade to about 42% of that obtained with a tie spacing of 20 ins. and 12 ins. of ballast, or it would make possible an increase of 140% in the intensity of the pressure from the moving load without increasing the maximum pressure per square inch as compared with that produced by the standard track. With this tie arrangement, no ballast would be required except a small amount of fine material to make surfacing possible during wet weather.

The End Tamping Bar.

But little attention has been given to increasing the strength of track by reducing the cross-tie spacing, probably for the reason that the almost universal method of tamping the ballast into the void between the bottom of the tie and its old bed produced by raising the tie to its proper position in connection with track surfacing, has been to use side tamping instruments such as the shovel, the side tamping bar and the tamping pick. The standard tie spacing of 20 ins. leaves about as small a space between ties as will permit of the satisfactory use of these side tamping tools.

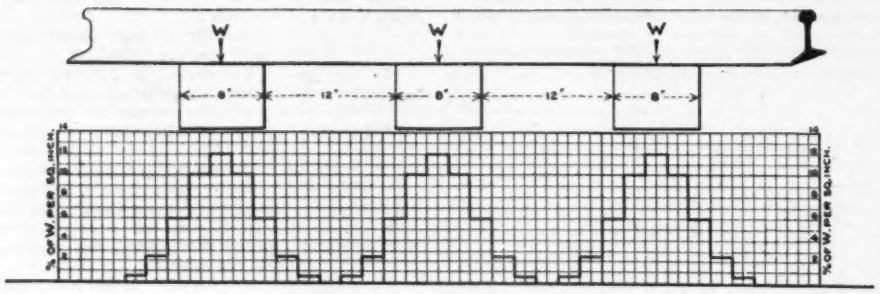
For a number of years a tool, supposed to have originated in Germany, has been used here and there in America for the purpose of tamping the tie from the end instead of from the side; Fig. 8 shows the tool, and Fig. 9 shows it in use. The presence of fine particles of ballast is necessary in order to make possible the use of this tool, but this fine material is also necessary with the side tamping tools if the old bed is not to be broken. It is, of course, not necessary to the success of end tamping that all the ballast be of fine material, but only that there be sufficient fine material to fill the voids to be tamped.

Due partly to its being unnecessary to excavate the material from between ties in using the end tamper, as is necessary in using the side tamper, the end tamper is from two to four times faster in its work than any of the side tamping tools and, in the hands of an expert better work is usually performed. End tamping by means of an air blast has also been tried but not very successfully.

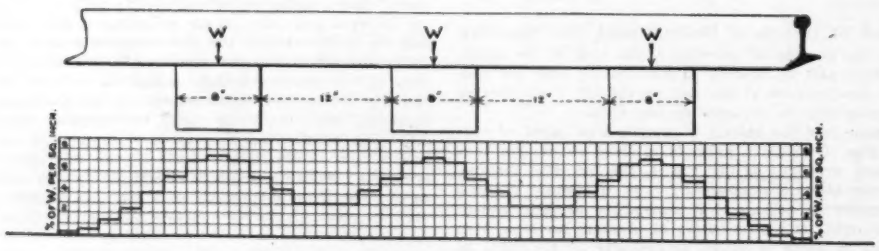


Pressure diagram, various depths of ballast. (A)

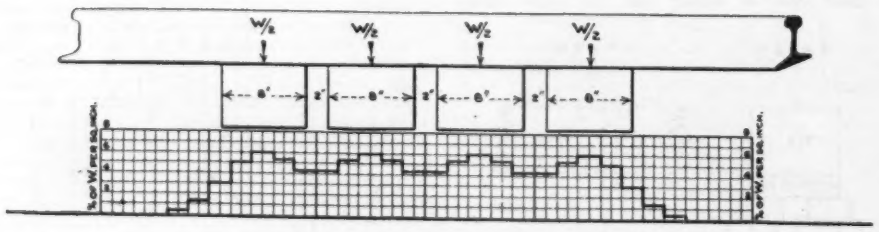
Pressure diagram, various sizes of ballast. (B)



Pressure distribution by 12" of 2" ballast-20" tie-spacing. (C)



Pressure distribution by 48" of 2" ballast-20" tie-spacing. (D)



Pressure distribution by 12" of 2" ballast-10" tie-spacing. (E)

FIG. 6. COMPARATIVE DIAGRAMS OF PRESSURE DISTRIBUTION ON SUBGRADE, SHOWING EFFECT OF DEPTH OF BALLAST, SIZE OF BALLAST AND TIE-SPACING.

Improving the Subgrade.

The most suitable materials for subgrade are rock, sand or other porous material which offers good natural drainage, and whose supporting power is not materially reduced by the presence of a small percentage of water. The most unsuitable materials are plastic clay, quicksand, etc., which have a greatly reduced carrying power in presence of water.

The selection of material for subgrade is usually confined by economic considerations to that in the cuts, or to the material at the sides of the fills of the roadway. The sole remaining method of increasing the carrying power of the subgrade, where satisfactory material is not obtainable, lies in thorough drainage.

DRAINAGE.—The necessity for drainage of the subgrade is usually brought about by one or more of the following conditions:

1. Presence, under the subgrade, of springs for which proper outlet was not provided at the time of construction.

2. Small irregularities in the surface of the subgrade which permit the formation of pools of water. The ballast protects these pools from the direct rays of the sun and prevents rapid evaporation and, consequently, if the soil is of such consistency that it will not readily permit of this water escaping through it, a gradual softening of the subgrade results, and the softened material moves up vertically between the ties, or laterally, causing a settlement of the ballast and track and increasing the depth and capacity of the pool.

3. Overloading the subgrade, causing the ballast gradually to settle into it and, if the subgrade is not of porous material, forming water pockets which gradually soften the subgrade and cause movement of the softened material.

4. The construction of shoulders along the sides of old embankments, either for the purpose of widening them to increase their strength or for the purpose of forming subgrade for additional tracks, these shoulders being carried above the bottom of the porous material (ballast, etc.) of the old grade and consequently acting as a dam causing water to collect in the old porous material. This water, on grades, sometimes finds its way for long distances to some point where it is intercepted by an obstruction across the track, such as a bridge or culvert, and at such points the roadbed is softened, causing movement as before explained and sometimes serious slips of the entire subgrade.

The method of remedying such troubles varies in individual cases, the use of cross trenches filled with cinders or other porous material and carried below the bottom of the water pocket, the use of tile drain and similar methods, being generally the most efficacious. The one point necessary to observe in order to secure permanency of treatment is to carry the bottom of the drainage system below the bottom of the moving material and below the bottom of the pool of water. Fig. 10 illustrates some of the above conditions and the remedy applied.

Substitutes for Wooden Ties.

The cost of wood in America has not yet reached the point where the application of preservatives to wooden sleepers is resorted to except on a comparatively small percentage of the total mileage; much less has the price risen to the point where it bcomes economical to substitute other materials for wood, although a number of experiments have been made. These experiments have resulted in practically eliminating all other materials but steel and reinforced concrete. So far, although a number of types of steel and reinforced concrete ties are under experiment, none have given such satisfaction as to have caused their general acceptance as being satisfactory designs.

The only extensive use of the steel tie is by the Bessemer & Lake Erie R. R., which is one of the subsidiaries of the United States Steel Corporation. This road has, for a number of years, gradually replaced its wooden ties with steel ties of the I-beam type. A number of other lines have experimented, on a very limited scale, with the same type of tie and some criticisms have resulted therefrom, among others being the following: 1. That the tie is displaced in the ballast more easily than the wooden tie; 2. That difficulty has been ex-

perienced with insulation where track circuits are used; 3. That, in case of derailment the track and equipment are more seriously injured than where the wooden tie is used; 4. That there is more difficulty in holding the track in line and surface than where the wooden tie is used. All of these criticisms are matters of controversy which have not been adjusted.

A number of designs of reinforced-concrete ties have been experimented with, but the tendency appears to be to regard this material as more suitable for side tracks and for main track at slow-speed points than for use on high-speed tracks.

Cross-Section of Rail.

Some years ago, the American Society of Civil Engineers undertook to assist in bringing order out of the chaos of rail sections in America by designing standard sections of different weights between 60 and 100 lbs. varying by 5-lb. intervals. Although the sections were adopted by a large number of lines, they were not universally adopted, the Pennsylvania R. R. being one of the important lines which did not adopt them.

Since the production of these recommended standards, the subject of rail sections and specifications has been one of growing interest and importance to the railroads of America, and, finally, in 1907, the matter was taken up by the American Railway Association through a committee representing both the railroads and the manufacturers, resulting in the tentative adoption of specifications for Bessemer steel rails and two sets of rail sections varying by 10-lb. intervals from 80 to 120 lbs. per yd. The Association recommended these specifications and sections as being an improvement on those formerly in use, and also recommended a system of reports to be used in connection with further investigation of the subject, which was referred to the American Railway Engineering & Maintenance of Way Association to continue.

Almost coincident with the work of the American Railway Association, the Pennsylvania R. R. appointed a committee to cover the same subject; this committee had several members in common with the American Railway Association committee, and it also contained representation from both the railroads and the manufacturers. The result of its work was a set of specifications for Bessemer and for basic open-hearth steel rails, a system of reports for use in further study of the subject, and a design for an 85-lb. and a 100-lb. rail, the design closely approximating the B section proposed by the American Railway Association.

The most important point at issue between the different members of the two rail committees, and likewise the principal point of difference of opinion which, in the past, has stood in the way of the general adoption of the recommended standard of the American Society of Civil Engineers, is the depth of the rail head. Inability to agree on this point led the committee of the American Railway Association to propose the two sets of standards. The American Railway Association committee in its report commented on this situation as follows:

> The Committee endeavored to unite upon a single design or type of section for all roads, but owing to the varying conditions throughout the country, or to the fact that there are many adherents among railroad engineers to each of two distinct types, it seems out of the question at the present time to reduce the number of types to less than two.

A study of the work of these two committees, and of the work performed by others on these lines, indicates a pretty general agreement upon the following principles which should be followed in the design of a series of rail sections, many of these principles being specifically stated in the two committee reports referred to.

1. The sections should be so proportioned as to possess, for the amount of metal contained, as great an amount of stiffness and strength as may be consistent with securing the best conditions of manufacture and the best service.
2. In addition to the metal necessary to develop the proper strength and stiffness of section, additional metal must be placed in the head in order to provide for wear requirements. (It is important to note that this additional head metal must either add to the weight of the section, or it must be secured by reducing the height of the web and the consequent stiffness of the rail.)
3. There should be such a distribution of the metal (including the surplus metal in the head) between the head, the web and the base, as to secure control of temperature in the manufacture of the rail.
4. Details:

(a) The bearing surface of the splice bar under the head of the rail should be sufficient to prevent crushing of the material.

(b) The slope of the under side of the rail head (as well as the slope of the upper side of the base) should be sufficient to permit the taking up of wear without too great a movement of the splice bar toward the web of the rail.

(c) The radius of the corner joining the under side of the head to the side of the head, and the radius of the top and bottom corners of the base, should be as small as practicable under mill requirements.

(d) The radius of the fillet uniting the side of the web with the line forming the under side of the rail head should be as large as possible, on account of its importance in lending support to the overhanging portion of the head; it is limited by the width of the head and by the portion required for the splice bearing. The depth of the head may be made less with a large fillet than with a small one on account of the better support afforded thereby.

(e) The radius of the side of the web should be such as to give ample area to the web at its junction with the head and the base, and still not unduly reduce the thickness of the web at its middle point.

(f) The thickness of the web at its middle point must be sufficient to afford proper strength to the rail, acting as a beam.

(g) The depth of the web should be sufficient to permit of the use of splice bars of sufficient strength and stiffness; also, this dimension is an important factor in determining the stiffness and strength of the rail.

(h) The width of the head should be such as to secure the most economical wear of rail and wheel, and, at the same time, to offer as broad a support as possible to the cast-iron wheel. It should, from this point of view, be the same for all weights of rail, were it not for the fact that it is necessary, for the outer rail on curves, to provide additional metal in the side of the head in order to prevent the destruction, by side wear, of that portion of the metal in the head necessary for strength and stiffness. (In the tables, the width of the head is measured from the lower end of the curve uniting the top with the side of the head.)

(i) The radius of the top of the head determines the area of support offered to the wheel by a new rail; the flatter the radius, the larger the area of support.

(j) The radius connecting the top to the side of the head should be made as large as practicable in order to reduce the strain on the overhanging portion of the head, and also in order to lessen the wear of the wheel at the root of the flange.

(k) The depth of the head must be sufficient to provide sufficient strength against shearing, and also to provide additional metal to be destroyed by the wear incident to traffic.

(l) The sides of the head are formed by joining the outer curves of the top and bottom of the head.

(m) Width of base should be just sufficient to make possible the prevention of over-turning without the incurring of excessive expenditure in the correction of this class of distortion.

(n) The minimum depth of the base should be such that the outer edges will cool sufficiently slowly to permit of the completion of the rolling of the rail head at a low enough temperature to secure a tough and homogeneous material; the maximum depth is determined by the necessity for supplying sufficient area to properly balance the area of the rail head and thus place the neutral axis of the rail section at, or near, the center of the rail.

(o) The sides of the base are formed by joining with vertical lines the fillets at the top and bottom of the base.

There seems to be but little difference of opinion among students of rail design in regard to these principles, but there is much dispute as to some of the facts to be used in their application.

THICKNESS OF BASE.—The three new sections have considerably increased the thickness of the base as compared with the old Am. Soc. C. E. design, this change being a result of experience with the old section, it having been found impossible to complete the rolling of the head at sufficiently low temperature for best results, because of the prior arrival of the temperature at the base at so low a point that further working becomes impossible.

DEPTH OF HEAD.—As already stated, the most important point of difference of opinion now existing as to rail design is with regard to the depth of the head. The report of the American Railway Association committee leads to the belief that this committee had not, at the time of making its report, abandoned the hope that a single type of rail section, satisfactory to all users, could be designed and, in fact, the securing of this single type of section was one of the objects in view in delegating the further consideration of the subject to the American Railway Engineering and Maintenance of Way Association.

The principal factors in the differences of opinion with regard to the proper depth of rail head are two

FIG. 7. CLAY SUBGRADE FORCED UP INTO BALLAST BETWEEN TIES.

FIG. 9 THE END TAMPING BAR IN USE

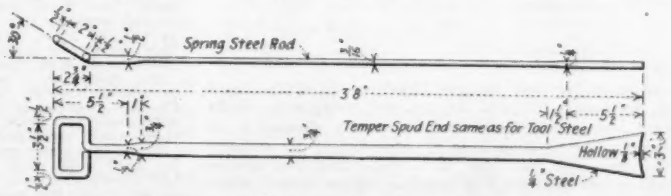


FIG. 8. SKETCH OF END TAMPING BAR.

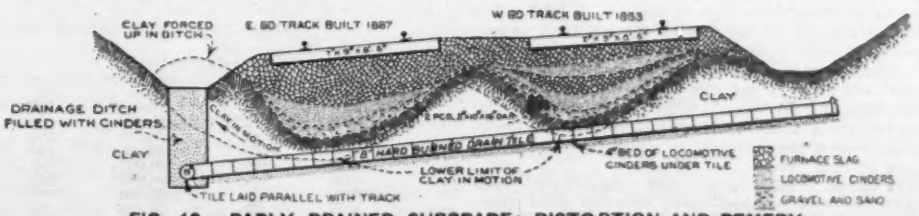


FIG. 10. BADLY DRAINED SUBGRADE; DISTORTION AND REMEDY.

in number. The first is that quite a number of rail failures, in the past, have taken the form of longitudinal splitting of the head, and one group of observers claims that this splitting is invariably due to defects in the material, these defects being principally due to the presence of slag and other impurities, and being generally known under the term "piping," while the other group of observers claims that, though many failures of the rail head are produced as claimed by the first group, still there are a number of failures due to the shearing of the head, because of its depth being insufficient to furnish proper strength. The cause of this difference of opinion, which is entirely one of fact, seems to lie in inaccurate and imperfect observations and records, which cause will no doubt be eliminated by the system of observation and records proposed by the American Railway Association.

The second factor in the difference of opinion as to the depth of the rail head, is one of local conditions, and is due to the difference in the percentage of straight to total track, and in the average degree of curvature of the curved track of the different railway systems; some railroads have as high as 50% of curved track, whereas on others the amount of curved track is as low as 10%.

RAIL WEAR ON STRAIGHT AND CURVED TRACK.—A single type of rail for use on both curved and straight track, which would be economical on lines of much curvature, would not be economical on lines of little curvature, as the following generally accepted statements in regard to rail wear will indicate:

(a) On straight line, the rejection of rail, due to service, is brought about by a combination of three conditions, viz.: A small amount—about 4 lbs. per yard—of the top of the rail head wears off in an uneven manner, producing a rough riding surface; this roughness is accentuated by surface bending of the rail over and between the supports; and there is also a tendency for the rail head to batter, a few inches from the end, generally about over the first bolt hole, the exact position depending upon the average speed of trains, and the battering being caused by the wheels jumping from rail to rail, this consequently being especially noticeable on tracks used solely in one direction.

(b) The long series of tests of Mr. Conrad, Engineer Maintenance of Way of the Paris, Lyons & Mediterranean Railway, indicates that rail wear on straight lines, occurs less rapidly the stiffer the rail, and his conclusion was that the wear increases in inverse proportion to the deflection. This result has, in a general way, been confirmed by experiments of the Pennsylvania Lines and others, although the exact relation between stiffness and rate of rail wear was not definitely ascertained.

Such being the case, a rail designed solely for use on straight line and to contain a given amount of metal should possess sufficient depth of head to avoid danger from shearing and should, in addition, have sufficient metal added to the top of the head to provide for the amount of rail wear which may be expected to occur before the surface becomes too uneven to permit of longer satisfactory use of the rail. The remaining metal should be so placed as to secure the maximum stiffness consistent with the satisfactory rolling of the rail.

The inside rail on curves, in addition to the wear received on straight line, is subjected to a considerable grinding of the top of the head due to the sliding of the passing wheels and, consequently, in order to secure greater life, it is necessary to add metal to the top of the rail head; this added metal is of no value for use on straight line and, moreover, if the given weight of section is to be adhered to, it can only be obtained by reducing the depth of the web and, consequently, seriously reducing the stiffness of the rail and its wearing capacity on straight line.

A road having a large percentage of curved track could afford to sacrifice to a great degree the wearing quality on straight line in order to increase the wearing quality on curves, and herein lies the inability to design a single section of rail which shall be satisfactory to all railroads.

The outer rail on curves receives practically the same wear as on straight line and, in addition, is subjected to a severe grinding of the side of the rail head; consequently, in order to increase the wearing power of the rail designed solely for straight line, it would be necessary to add metal to the side of the rail head and this metal could only be secured, without increasing the total weight of the section, by reducing the depth of the web, the stiffness of the rail and its consequent serviceability on straight line.

DIFFERENT SECTIONS FOR TANGENT AND CURVE.—In view of these facts, it would seem desirable to consider the design of a rail for use on straight line only; then to modify this design [i. e. design a second form of rail section.—Ed.] by adding metal to the top and sides of the rail head in order to secure a section having a head economically designed for use on curves and using the same splice bar as the straight line section. Under such conditions, the rail sections would be economically applicable on lines of varying degrees of curvature, and the practical difficulties would be reduced to a minimum, inasmuch as the same joint material could be used, a compromise joint at each end the curve being the only special requirements.

Quality of Rail.

The principal points of discussion with regard to rail specifications, are the following:

1. Minimum percentage of phosphorus. The lower the percentage of phosphorus, the greater can be the percentage of carbon without producing a rail of dangerous brittleness and, consequently, the harder and more serviceable the rail. The amount of phosphorus depends upon the character of the ore and upon the process employed, much lower percentage of phosphorus being obtainable with the open-hearth process than with the Bessemer process. Practically, the percentage of phosphorus with the Bessemer process is dependent upon the relative amounts of marketable high and low grade ore. (It has been suggested that specifications, in addition to establishing a maximum and minimum composition, should indicate the composition desired to be obtained.)

2. Cropping of ingots: It has been found that most of the impurities in an ingot of steel are in the upper portion and, consequently, the greater amount of this portion of the ingot cropped off, the less danger from piping and other defects in the rolled shapes. It has been claimed that the necessary amount to be cropped varies considerably with the mode of manufacture, as for example, with the rate of pour, and with the length of time the ingot stands before solidifying.

3. The next most important feature to be controlled in the manufacture of rail is the temperature at which the final work on the rail head is performed. Above a certain maximum temperature, work produces little improvement in the texture of the material and below a certain minimum temperature, the effect is injurious rather than beneficial.

ALLOY STEEL.—The rapid wear of Bessemer and Open Hearth steel under heavy traffic on sharp curves has increased the interest in the securing of a material possessing greater durability and less brittleness.

Chrome-steel has been extensively used for ore stamps and other purposes for over twenty years. Nickel-steel has been in use in connection with the manufacture of armor-plate for about the same period. Steel containing tungsten was manufactured by Mushet, who was Bessemer's rival, and manganese steel is nearly as old as the other mentioned.

Recently, vanadium and titanium have attracted attention. The older alloys, such as chrome-vanadium steel, containing 1 to 2% vanadium, have shown most remarkable properties, one of the highest tests yet obtained after a special heat treatment being a maximum breaking strength of 103 tons per sq. in., the steel showing, at the same time, a great resistance to bending and dynamic tests.

Recently, manganese-steel rail has been rolled, this rail having about the following composition:

	Per cent.
Manganese	11.5
Carbon	1
Silicon	0.3
Phosphorus	0.065
Sulphur	0.030

Some of this rail has been used on the sharp curves of the Boston Elevated Ry. Co. and remarkable results have been obtained, the tests apparently showing a resistance to wear from 20 to 80 times that of the ordinary Bessemer steel rail; also, its extreme toughness greatly reduces the possibility of breakage under traffic. Some titanium-steel rail has been rolled and the indications point to its possessing qualities superior to those of the ordinary steel.

There seems no doubt that alloy steels can be manufactured which will be as much superior in wearing quality to the Bessemer steel rail as that was superior to the iron rail which it replaced many years ago. As in the case of the Bessemer steel vs. the iron rail at that time, the cost of the alloy steel today is so much greater than that of the Bessemer steel as to interfere with its use except under especially severe conditions, the interest on the greater cost of the alloy rail more than counterbalancing the saving by reduced rate of wear.

Conclusions.

The relative unit prices of rail, ties, ballast and labor vary so greatly at different times and places, that the determination of the economic order of strengthening of roadway by resorting to heavier rail, closer tie spacing, greater depth of ballast, or by draining the subgrade, must be left to special individual determination.

The extent to which the present standard American track can be strengthened by a combination of these items, is so great in proportion to the probable increased requirements of higher speed in the near future as to make improbable the immediate need for a radical change in the type of roadway construction.

The economic possibilities in the way of roadway strengthening by means of closer tie spacing, made possible by the use of the end tamper, deserve careful investigation.

Economy of maintenance is probably frequently secured by the use of a stiffer track but, due to obscuring factors, the amount of economy secured is practically indeterminate.

The use of one rail section especially designed for straight track, and one or two rail sections especially designed for curves, offers possibilities of economy in rail wear and should be further investigated. No compromise section of rail can be designed which will be economical under all conditions of curvature.

The increase in the allowable per cent of carbon in rail steel, due to the reduction in the percentage of phosphorus, obtainable by the use of the basic open-hearth process, results in a steel of such superior qualities as to point to the gradual abandoning of the acid Bessemer process as the high-grade ores with low per cent of phosphorus become exhausted.

Alloy steels offer such great possibilities of future usefulness that the development of the processes of manufacturing should be encouraged with a view to the ultimate reduction of the cost of the product.

The design of the rail section so as to permit of the rolling of the head at low temperatures, is of the utmost importance.

Slow pouring of the ingot and close attention to cropping, to eliminate impurities, is necessary in order to avoid the production of rails with dangerous defects.

The experimental use of steel and of reinforced-concrete ties should be continued in view of the decreasing timber resources, but economic conditions are not yet ripe for the extended use of these substitutes for the wooden tie.

A STATE TRUNK ROAD 1,100 miles long has been proposed by Hon. Marion E. Hay, Governor of Washington. It is said that the road would serve 937,500 of the 1,250,000 population of the state, and would touch eleven cities. The following interesting remarks on state roads in Washington are credited to Governor Hay:

The largest appropriation ever made for state roads was $225,000. Seventeen appropriations were made for improvement of state roads in 1909, and in no instance were these roads connected. I do not favor carrying on the work in this manner. I believe a route should be selected for a state road that would best accommodate the largest percentage of residents and then every effort be used in a continuous betterment of that route.

The route, as I have made out, will pass through or near Bellingham, Everett, Seattle, Tacoma, Centralia, Chehalis, Vancouver, Walla Walla, Spokane, Wenatchee, Ellensburg and again to Seattle. A road following this route would accommodate 75% of the people of the state.

There is no one man in the state that is doing more for good roads than Samuel Hill. Although what he has accomplished is well known in the western part of the state, the residents in the eastern part are not so generally acquainted with his work along this line.

Soon after I was elected Governor, Mr. Hill came to me and said he would give one full year of his time wholly in the interests of better roads in the state. He has done as good as his word and even better, for he has spent thousands of dollars in furthering plans. He has given to the state a machine for the spreading of roadbed material. He has paid the expenses of one of the best road engineers in England to go to Seattle and deliver an address. Upon his invitation, R. H. Thomson, City Engineer of Seattle, and Professor Samuel Lancaster, of the State University of Washington, were taken to England and enjoyed a three months' trip inspecting roads in that country.

TABLE II.—RAIL STRESSES WHEN RAIL SPANS ACROSS TWO TIE-SPACES.

Rail: Moment of inertia.	Rail: Approximate weight, lbs. per yd.	Axle load.: Lbs.	Axle load.: %	Tie spacing center to center.: Inches	Tie spacing center to center.: %	Maximum unit-stress in Rail.: Lbs. per sq. in.	Maximum unit-stress in Rail.: %	Maximum unit-stress in Rail.: Reciprocal %
22.9	75	60,000	100	20	100	32,200	157	64
26.2	80	60,000	100	20	100	30,000	146	69
30.0	85	60,000	100	20	100	27,300	133	75
34.0	90	60,000	100	20	100	25,000	122	82
43.8	100	60,000	100	20	100	20,600	100	100
59.0	110	60,000	100	20	100	16,900	82	121
69.2	120	60,000	100	20	100	13,900	67	148
22.9	75	38,000	64	20	100	20,600	100	100
26.2	80	41,000	69	20	100	20,600	100	100
30.0	85	45,000	75	20	100	20,600	100	100
34.0	90	49,500	82	20	100	20,600	100	100
43.8	100	60,000	100	20	100	20,600	100	100
59.0	110	72,800	121	20	100	20,600	100	100
69.2	120	88,500	148	20	100	20,600	100	100
43.8	100	60,000	100	20	100	20,600	100	100
43.8	100	60,000	100	16	80	16,490	80	125
43.8	100	60,000	100	10	50	10,300	50	200
43.8	100	60,000	100	8	40	8,300	40	250

Annual Convention of the Illinois Society of Engineers and Surveyors.

The 25th annual meeting of this Society was held at Cairo, Ill., Jan. 26 to 28, the headquarters being at the Halliday Hotel while the meetings and exhibits were in the Armory Hall. At the opening meeting, at 2.30 p. m., Jan. 26, an address of welcome was delivered by the mayor, Mr. George Parsons, who referred to the public works and improvements built and contemplated by the city. This was responded to on behalf of the Society by Mr. J. G. Gabelman, of Chicago. The annual address was then read by the President, Mr. John B. Hittell (Chief Engineer of Streets, Chicago), who took as his main subject the advantages which membership in such a society offer to the young engineer, especially in regard to the character of the papers read and published and the opportunity for the younger men to make a beginning in the work of preparing papers and reports, a work which becomes of increasing importance to him as he progresses in his career. The preparation of articles describing some work done, plans made or difficulties overcome (as well as the reading and discussion of such articles) are a training in the logical arrangement of ideas and their correct expression in such a way as to make them both forcible and clearly understood.

A paper on "Municipal Engineering at Cairo," by Mr. W. B. Thistlewood, City Engineer, explained some of the special difficulties due to the site. Situated on a point of land at the junction of the Ohio with the Mississippi, the protection of the site against floods by means of levees was a first requisite, and then the area was gradually filled in to a certain level. The filling has been done by various methods, including the use of hydraulic dredges and sand pumps. In times of high water in the rivers, accumulations of ground water, storm water seepage and sewage within the protected area is removed by two pumping plants. This is necessary for an average of 10 weeks per year. The rivers have a range of 52 ft. in rise and fall; the streets are from 9 ft. to 12 ft. below high water mark, and the outfall of the sewerage system is approximately midway between high and low water elevations. The outlet is fitted with an automatic flap valve. There is a main trunk sewer 9,700 ft. long, 4 to 6 ft. diameter (built of concrete), and pipe laterals aggregate 35 miles. The trenching for the main sewer was done with a Potter machine, and steel centering was used. The paving is largely of brick on a 5-in. concrete base, with both cement and asphalt grout. The street railway tracks have 7-in. tee-girder rails laid on wooden ties on 6 ins. of concrete, and concrete is filled in between and over the ties to the proper level for the brick paving, with a 2-in. sand cushion.

WATER SUPPLY.—Dr. E. Bartow, Director of the State Water Survey, presented a paper on "The Relation of the Typhoid Fever Death Rate to the Water Supplies in Illinois," showing the high rate where the supply is from streams as compared with the low rate where deep wells are used. We shall give an abstract of this paper. A paper by Mr. Robert I. Randolph, of the Illinois Internal Improvement Commission, on "Water Supply and Drainage Investigations," reviewed the cooperative work of the State Water Survey and Geological Survey and the Commission in regard to measurements of stream flow, etc. Mr. W. B. Dole, of the U. S. Geological Survey, discussed "The Mineral Properties of Waters in the Mississippi Basin." Dr. Bartow presented also the report of the Water Works Committee, and a paper by Mr. G. C. Habermeyer (University of Illinois) outlined the courses of "Instruction in Hydraulics and Water Supply Engineering at the University of Illinois."

SEWERAGE AND SEWAGE DISPOSAL.—Mr. J. W. Dappert (Taylorville) presented the report of the Committee on Sewers, which was a compilation and tabulation of sewerage and disposal systems in a number of Illinois cities; the list included 35 having the separate system, 43 the combined system, and 6 having both systems. As to disposal, 21 of the places on the list have septic tanks, and 8 have settling tanks and filters. Mr. W. D. Gerber (Chicago) reviewed "Present Practice in Sewage Purification," in which he pointed out that the septic process did not give complete purification (though it reduced the suspended matter about 50%), and that filtration has been added in order to give a non-putrescible effluent. The most common forms of filters are (1) contact beds, (2) sand filters, and (3) sprinkling filters.

A short paper by Mr. Pearse (of the Chicago Sanitary district) described the purpose and construction of the experimental sewage purification plant installed by the District. This plant we shall describe shortly. An interesting paper by Mr. G. C. Habermeyer (University of Illinois) on "Sewage Disposal Plants for Small Institutions" described a number of plants of this special character. These included are described by Mr. J. W. Alvord in Engineering News of July 2, 1903.

STREETS AND PAVING.—A paper by Mr. N. E. Murray (Superintendent of Streets, Chicago) presented "Chicago's Sidewalk Problem" at some length. He outlined the organization and work of the Bureau of Sidewalks, and the methods of construction of concrete sidewalks and concrete and reinforced-concrete vault walks, or walks over sub-sidewalk space in the business streets. His disapproval of limestone screenings for use in concrete for sidewalk purposes led to considerable discussion. The author claimed that the results were entirely unsatisfactory, although he admitted that this may have been due to the character of the screenings or an insufficient amount of cement; he thought that in spite of their satisfactory use in mass concrete for underground and foundation work, they are not suitable for concrete in such exposed conditions as sidewalks. Mr. Woermann (St. Louis), supported the argument in favor of the use of screenings. A paper by Mr. W. W. Marr (Board of Local Improvements, Chicago), on "Materials Versus Workmanship in Street Paving," showed that good materials and proper workmanship combined give the best results; but inferior materials and skilful work may give better results than first-class materials and careless or incompetent work.

A paper by Mr. R. B. Slippy (University of Illinois) outlined the system of "Instruction in Road and Pavement Construction at the University of Illinois."

HIGHWAYS.—A paper on "Earth, Gravel and Macadam Roads," by Mr. M. O. Eldridge (Office of Public Roads, U. S. Department of Agriculture) dealt with the location, construction and maintenance of public roads. The location must be governed by economic as well as engineering conditions, and the paper discussed the coordination of these conditions. The present road tax system was condemned by Mr. J. O'Brien (Champaign) in a paper on "Good Roads in Central Illinois." He advocated a special assessment law (similar to the drainage law) by which the cost would be distributed between the property affected, the towns and villages, and the state. The automobile tax should also be paid into the road funds. Where gravel is not obtainable, he favored the paving of the main country roads with brick.

"Tests of Road Materials" was the subject of a paper by Mr. R. B. Slippy (University of Illinois), which described the equipment and work of the road materials testing laboratory established at the University of Illinois in 1903 under the direction of Prof. I. O. Baker. Commercial tests are performed upon request, for which a fee is charged to cover the actual cost of the tests. Brick, broken stone and gravel are mainly submitted for this purpose, and are subjected to impact, abrasion, hardness and cementation tests. The impact and abrasion tests of stone are now made in a Deval machine, which has four cylinders 8 × 13½ ins. on a longitudinal shaft, with the cylinder axis at 30° with the axis of the shaft. In these are placed charges of the stone. For the abrasion test, a weighted specimen is placed upon the horizontal revolving disk of a Derrey machine. For the impact, to determine the resistance of the material to blows from horses' hoofs, the machine resembles a small pile driver with a 4.4-lb. hammer falling ⅛-in. to 39⅛ ins. Various other tests of an experimental nature have been conducted, among the most interesting of which are those on the comparative merits of cement and asphalt fillers for brick paving, and the transverse strength of brick paving. Other tests have indicated that brick pavement on country roads can be so constructed as to compete favorably with the more expensive macadam roads, treated with dust preventatives or wear-reducing compositions.

Mr. A. N. Johnson (State Highway Engineer) presented an illustrated talk on road and bridge work, including work done by convict labor.

LAND DRAINAGE.—Several papers were presented dealing with different phases of this question, which is an important problem and affords much work to engineers in Illinois. One by Mr. C. W. Brown (Jacksonville) discussed "The Drainage and Protection of Lands Subject to Overflow," while another by Mr. J. V. Waddell (Vandalia) presented some features of "The Legal Liabilities of Levee and Drainage Districts." In a paper on "The Maintenance of Open Ditches" Mr. E. H. Cowan (Luverne, Ia.) showed the necessity for and the general neglect of this feature in drainage, and also discussed the proper methods of maintenance.

"The Tallahatchie Drainage District (Mississippi)" was described in a paper by the assistant chief engineer, Mr. A. L. Dabney (Clarksdale, Miss.). The district has an area of 1,900 sq. miles. A survey of part of the district was made by the U. S. Geological Survey by special arrangement, and the drainage commission organized two parties of 35 men each. Investigations were made as to rainfall, run-off, stream flow, flood heights, and amount of sediment carried. As a part of the work, the Coldwater River will be diverted into the Mississippi north of the drainage district by means of a canal and an earth dam 5,000 ft. long, 45 ft. high, 10 ft. wide on top, with slopes of 1 in 6 and 1 in 8. About 1,500 HP. will be developed by a power plant at the dam, and current transmitted 30 miles to Memphis, Tenn.

SURVEYING.—This is another subject which always receives considerable attention at the Society's meetings. Mr. W. P. Feeney (Chicago) presented a brief report for the Committee on Surveying, calling attention to the necessity of establishing permanent monuments for corners in all cities, towns and villages. The special committee on Government Regulation of Land Surveys reported the failure of a bill presented in the Illinois legislature to require the licensing of surveyors. This move has been made many times, but always without success, but nevertheless the committee was continued. The special committee on Standard Measures of Length reported that in view of the accuracy and general use of steel tapes instead of link chains, and the nominal cost of sending such tapes to Washington to be tested, there is no good reason for recommending the establishment of a standard measure of length at every country seat.

Dr. W. F. M. Goss (Dean of the College of Engineering at the University of Illinois) presented the report of the special committee on The Metric System. The general conclusion was as follows:

> The superior advantage of the metric system does not admit of serious question. It is already used in this country by a large class of influential people. Most scientists use it, and manufacturers of machinery for export find no great difficulty in working to the drawings and specifications of metric countries. Its use is sure to become more and more general, and it would seem the part of wisdom to encourage its gradual absorption by the various activities of the country, so far as this can be done without serious sacrifice.
>
> The attempt to force its adoption by legislation is not to be encouraged. The feasibility of its use in the several fields of activity to which the system applies is a matter which must be worked out gradually and without legislative interference, at least in the present state of its development.

MISCELLANEOUS. — A number of other branches of engineering work were covered by other papers which were read and discussed. "Reinforced-concrete Aqueducts on the Illinois & Mississippi Canal" were described by Mr. H.

E. Reeves; and reinforced-concrete building construction (with particular reference to the Kahn system), by Mr. A. J. Widmer. Municipal ownership of public utilities was discussed in a paper by Mr. J. W. Dappert, and in the discussion Mr. A. B. Alexander (Decatur) described a proposed municipal tunnel system for underground wires. Mr. Geo. F. Dewey (Cairo) described the construction of the new Cairo & Thebes Ry., the purpose of which is to connect the city with the several railways using the great cantilever bridge over the Mississippi at Thebes, and to furnish ample terminal facilities for their business.

Mr. J. W. Woermann (St. Louis, Mo.) read a paper on "The St. Louis and Cairo Division of the Proposed Deep Waterway." Two papers described special features of educational work at the University of Illinois: (1) instruction in railway engineering, by Prof. S. S. Roberts, and instruction in mining engineering by Prof. H. H. Stoek. The Society has always kept in close touch with the engineering department of the University, and other papers by its staff have been noted above. Prof. F. O. Dufour gave an illustrated talk on observations made during a trip in Europe. A number of "topical subjects" were submitted, and some of them received a scattering discussion.

The attendance was large and included a number of visiting engineers from neighboring towns in Illinois, Missouri and Kentucky. There were also a number of ladies in the party for whom special entertainments were provided. The general entertainments included (1) a trip by special train on the Illinois Central R. R. to the long truss bridge (with nine through spans over the channel) across the Ohio River at Cairo and to the cantilever bridge at Thebes; (2) a short steamboat trip on the Ohio to its junction with the Mississippi; (3) a "smoker" at the Alexander Club, and (4) a dinner at the Halliday Hotel. The mayor, Mr. George Parsons, took active part in the arrangements, and Mr. W. B. Thistlewood (City Engineer) was chairman of the local committee.

The report of the secretary and treasurer (E. E. R. Tratman, Chicago) showed a membership of 225 at the end of 1909, and 18 new members were elected at the meeting. The bank balance at the end of the year was $828. The election of officers resulted as follows: President, A. N. Johnson, State Highway Engineer, Springfield, Ill.; Vice-President, J. W. Dappert, Taylorville, Ill. The next meeting will be held at East St. Louis, Ill., in January, 1911.

Treating Timber with Crude Petroleum.*

By C. MARSHALL TAYLOR.†

With one or two exceptions it has not been possible as yet to formulate any definite results on the treatment of wood, in which crude petroleum (or combinations of it with other things) have been used. It is, therefore, only within my power to give a short resume of the status of the crude petroleum treatments.

It has been only recently that treatment of timbers with crude oil has been undertaken commercially. Two railways have adopted it. The National Lines of Mexico, at Aguascalientes, and the Atchison, Topeka & Santa Fe Ry., at Albuquerque, N. Mex. The former is using the Mexican crude oil, and the latter gets its supply from Bakersfield, Cal.

As yet it is purely an assumption, as to the probable results of this kind of treatment, because it is radically different from all past deductions as to the preservation of timber. Heretofore it has been considered essential to have in the preservative medium, an element that was either germicidal or antiseptic in its nature. This new treatment is depending upon an entirely new conception of preservation, namely, the elimination of air or oxygen and moisture. This has for its basis the well-known fact that in order that fungi may thrive, there must be present three essential conditions: moisture, air or oxygen, and the proper temperature.

Therefore, this crude oil treatment gets its impetus from the fact that it probably will be (1) a weatherproofing agent, as the tie is thoroughly impregnated with the oil, and (2) that the fungi will not be able to thrive, from the presence of any moisture which may have been left in the timber previous to treatment, due to the absence of oxygen or air.

The various crude oils which are in use either commercially or experimentally, have been examined as to their germicidal or antiseptic properties, and from all known tests covering such work, none of them contain any such properties.

The first oil to be used in the United States commercially was the Bakersfield oil. Timbers treated with this oil have been in the experimental track of the Gulf, Colorado & Santa Fe Ry., near Pelican, Tex., for over three years, and some ties taken out recently for examination were entirely free from all indications of decay. This is promising, though not convincing, that the treatment has its merits; that it will preserve the tie for its mechanical life.

Recently the Santa Fe Ry. has investigated other oils, more especially a Mexican oil from Ebano. Another oil from Oklahoma has been tried. (The characteristics of these oils are summarized in the accompanying table. —Ed.)

Pine has been the principal wood used in the experiments. The gums required a considerable longer time and a higher pressure. Using Ebano oil on gum ties, one experiment gave an absorption of 55 lbs. per tie, yet the ties were somewhat checked from being subjected to such a high pressure (175 lbs.) and a high temperature (200° F.).

There is, apparently, no difficulty in thoroughly impregnating all the sap wood of the different species of pine. In the case of the loblolly, it is thoroughly saturated. All the sap of the shortleaf and some of the heart receive treatment, while with the long-leaf, the penetration is confined entirely to the sap wood.

With crosoted ties, it is not unusual to find that after they have been air-seasoned a year after the treatment they weight less than they did when treated. Such is not the case with the crude oil treatment. Seasoning tests with the three oils gave the following tie results, after seasoning ten months: 27 ties treated wth Bakersfield oil lost an average of 2.6 lbs. each; 30 ties treated with Oklahoma oil lost an average of 14.3 lbs. each; 30 ties treated with Ebano oil lost an average of 14.4 lbs. each.

The crude oils are viscid at ordinary temperatures, but do not affect pipe lines during treatments. The oil is used at a tempearture varying from 175° to 200° F.

Checking seems to be reduced to a minimum with this treatment, except in a few cases where it was necessary to use great pressure and high temperatures. On standing, any small checks that are formed, become filled with the oil, which forms a plug against the entrance of any moisture. On seasoning the ties after treatment, the oil has a tendency to form a coating on the outside. This forms a very insoluble covering to the whole tie, very much like the theoretical leather formation which was supposed to form in the Wellhouse process.

The Ebano oil does not mix with thinner crude oils, as it becomes coagulated, forming a sticky mass. At the outset of this treatment, two objections were suggested: (1) The ties would be inflammable, and (2) the spikes would be liable to work loose. Both of the objections never existed in actual practice, and no such conditions exist among ties treated with these crude oils.

The success of this treatment depends upon the fact that all the sap wood must be thoroughly impregnated and with all the oil that it is possible to force into them.

The National Ry. of Mexico has not much doubt that the Mexican pine ties will last their mechanical life, which they figure will be about five or six years when treated. They figure the cost to be less than 20 cts. (Mexican currency) per tie, and will answer their special requirements, if they get five or six years' life.

*Abstract of a paper read at the annual meeting of the Wood Preservers' Association, at Chicago, Jan. 19, 1910.
†In Charge of the Department of Chemistry and Tests, International Creosoting & Construction Co., Texarkana, Tex.

CRUDE OILS USED IN TIMBER PRESERVATION.

Oil.	Bakersfield (Cal.).	Oklahoma.	Ebano (Mex.).
Appearance	Dark, viscid.	Brown, syrupy, with green fluorescence.	Black, viscid.
Odor	Asphalt.	Sour petroleum.	Asphalt and sulphur.
Spec. gravity	0.965 at 38° C.	0.902 at 21° C.	0.918 at 60° C.
Distillation (p. ct.):	.....	.....	.....
Below 210° C.	.....	.....	2.07
210 to 235°	1.1	.....	1.77
235 to 270°	1.5	1.2	3.43
270 to 315°	6.7	3.4	6.01
315 to 355°	14.5	13.6	6.66
Residue, per cent	75.2	81.8	65.50
Residue, character	Black, thick, viscid.	Viscid, dark brown.	Black, sticky.
Boils at	70° C	120° C.	110° C.
Loss by evaporation after 12 mos. exposure in open vessel	None.	No tests.	7%

THE VALUATION OF THE PROPERTY OF DELAWARE Water Co., Delaware, Ohio, was recently made by Messrs. George Hornung, M. Am. Soc. C. E., Cincinnati, Ohio, and E. Kuichling, M. Am. Soc. C. E., New York City, the former representing the city and the latter the company. The two being unable to agree, Mr. W. Kiersted, M. Am. Soc. C. E., Kansas City, Mo., served as referee. A total valuation of $258,997 was put upon the plant divided as follows:

DETAILED SUMMARY OF THE VALUE OF THE PHYSICAL PROPERTY OF THE DELAWARE WATER CO., OF DELAWARE, OHIO.

Item.	Cost of Reproduction.	Depreciation.	Present worth
Pumping station and engine house	$17,475	$1,747	$15,728
Infiltration gallery and emergency intake	4,207	252	3,955
Water-supply wells and suction pipe	5,619	....	5,619
Boilers	3,685	1,468	2,217
Pumping machinery and connecting water pipe	12,877	2,200	10,677
Air compressor and air pipe	1,668	935	733
Auxiliary pumps	299	116	183
Electric light equipment	570	....	570
Suction and delivery pipes for all pumps	1,968	224	1,744
Steam pipe, heaters and coal track	990	147	843
Stand-pipe	7,383	1,477	5,906
Cast-iron water pipe in streets	127,545	5.078	122,467
Valves and hydrants	10,918	596	9,422
Meters	8,597	1,719	6,878
Road, grading, septic tank and fountains	2,155	10	2,145
Wrought-iron pipe in streets	600	12	588
Total	$205,656	$15,981	$189,675
To the present value of the plant of			$189,675
Add, For preliminary investigations, general administration, and legal expenses, engineering, supervision and contingencies, 10% of $189,675			18,967
			$208,642
For interest during one-half the period of construction of 18 months at 6% per annum, equivalent to 4½% on $208,642			$9,389
For real estate, rights-of-way and easements			10,119
For interest on real estate for the full period of construction of 18 months at 6% per annum on $10,119			911
For stock on hand			1,896
For going value or the cost of reproducing the business of the water company			28,040
Total present value of property			$258,997

Mr. Hornung informed us on Dec. 31 that the question of purchasing the works would be submitted to the voters.

THE CAPE COD CANAL is reported on as follows in the 31st annual report of the Board of Harbor and Land Commissioners of Massachusetts, 1909:

Under the provisions of the act incorporating the Boston, Cape Cod & New York Canal Co., the Board of Railroad Commissioners and the Board of Harbor and Land Commissioners were constituted a Joint Board for the purposes defined in said act.

On June 21, 1909, notification was received from the Canal Co. that the construction of the breakwater at the Barnstable Bay end of the canal had been commenced. This work is now in progress, and on Nov. 30, 1909, about 46,000 tons of stone had been placed in position. There has been, to the same date, about 230,000 cu. yds. of material excavated in Barnstable and Buzzards bays. On July 30, 1909, application was made by the Canal Co. for a permit to dump the material dredged from the approach channel of the canal in Buzzards Bay, at the dumping ground in said bay, located about one mile west of West Falmouth harbor, prescribed by the district engineer officer of the United States stationed at Newport, R. I. A permit was subsequently granted, authorizing the dumping of approximately 1,500,000 cu. yds. of material at the dumping ground aforesaid, subject to certain conditions. On Sept. 24, 1909, application was made by the Canal Co. for a permit to dump on the northerly side of the northerly breakwater at the Cape Cod Bay end of the canal, and in Cape Cod Bay in water not less than ten fathoms deep, material excavated from the canal, as prescribed by the district engineer officer of the United States stationed at Boston, Mass. On Oct. 1, 1909, a permit was granted authorizing the dumping of material in the locations prescribed as aforesaid, and subject to certain conditions and restrictions.

Under the law the Canal Co. was obliged to begin the construction of the canal within three months from the date of the decision of the Joint Board determining at what point the railroad of the Old Colony R. R. Co. should cross the canal. Construction was actually begun within the three months, but not actively continued, as is claimed, on account of the severe financial troubles in the fall of 1907. The actual work of construction was resumed in June, 1909, after nearly two years' delay. The Joint Board is assured that financial arrangements have been made and contracts covering the principal construction work entered into, and that the canal will be completed within the five years from June 3, 1907, the date of the decision of the Joint Board in respect to the railroad crossing of the canal.

There may be accidents and unavoidable delays. Unless the canal is completed by June 3, 1912, the act shall be null and void, as provided by the statute. In view of the contingencies and the losses which might accrue, the Board recommends that some reasonable extension of the time, in the discretion of the Joint Board, be permitted for the completion of the canal; otherwise, although the construction was substantially completed, the Canal Co. might be unable even to operate the canal, and both the company and the public thus be deprived of its use.

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Entered at the New York Post-Office as Second-Class Matter.

We present to our readers in this issue the complete report of the National Waterways Commission. So far as we have been able to learn, Engineering News is the only journal in the United States to publish this report in full. The report is long but the space we give it is fully justified by the importance of the subject to our readers. Engineers ought to be informed on this great subject of economic transportation. The general public may be and to a large extent undoubtedly has been misled by the huge agitation for waterway improvement, by the conventions and lecture bureaus, newspaper articles, and magazine contributions, and even the books, which the waterway schemers have spread abroad. But the engineer ought surely to test the soundness of the waterway arguments. He ought to have sufficient intelligence and sufficient knowledge of the foundation facts to be able to discern underlying fallacies.

At the present time the waterway agitation undoubtedly constitutes a great National danger. If the waterway boomers who have been so prominently before the public for the past year or two can carry their day, they would land the nation in an abyss of debt from which it would not emerge for a generation. It is, perhaps, fortunate, that the increasing cost of living tends to make the public pause and hesitate before lending the nation's credit to any such vast speculation. The public is in a mood to-day to ask for the proof that waterway improvements will really pay—will really yield a general benefit commensurate with their cost—before it sanctions any of these vast drainage schemes—schemes to drain the treasury—which have been so vehemently urged upon Congress by those who are supposed to represent the great industrial and commercial interests.

This preliminary report of the National Waterways Commission is the first and most authoritative answer to the question, "will waterways pay?" It does not tell the whole story indeed, and leaves of necessity many questions unanswered; but it does show the fallacy on which much of the current agitation for huge waterway expenditures is based. One of these fallacies, for example, is that waterways should be improved for their influence in lowering railway rates, even if the waterway were not actually used at all. Concerning this the Commission says:

> It is a transparent fallacy that the railways constitute an intrenched and uncontrollable monopoly which cannot be reached by legislation or other orderly and legal methods, and that the only way in which to compel them to lower rates is by the expenditure of large sums of money in the improvement of channels, which are to remain wholly or partially unused. National or state legislation is certainly sufficient, and should be resorted to for securing proper reductions in railroad freight rates. Again, the subject of transportation should be considered as a great economic problem. The cost of facilities for carrying freight, whether borne by the Federal Government of by private capital, is a burden upon the resources of the country. The fundamental criterion should be whether a railway or waterway, when constructed or improved, will be a profitable investment of capital.

Again the Commission gives a quietus to the constantly recurring fallacy that canals can be revived with profit at the present day. It points out that the only canals justifiable at the present day are those which connect bodies of water already carrying large traffic, such as the Welland Canal or the Suez Canal, or those which connect cities located a short distance inland, with the sea, such as the Manchester Canal.

It might have added that most canals even of these classes are not now carrying sufficient traffic to make the investment in them profitable.

It is to be remembered in reading the report that it is the unanimous statement of a Commission of twelve congressmen, none of them engineers. Also that since some of its members were originally numbered among the most vociferous advocates of huge expenditures on waterways, the report doubtless is in some respects a compromise. Nevertheless the report is the most enlightening document that has thus far reached the American public upon this much debated public question, and is bound to have very great influence in checking the threatened raid upon the national treasury.

It is of interest in this connection to note that Chicago, which has been foremost in booming the "Lakes to the Gulf Deep Waterway," appears to be rapidly changing front. Three prominent Chicago dailies, the "Record-Herald," the "Tribune" and the "Interocean" are now confessing that they "succumbed to the fascinations of a dream." Says the "Tribune": "We saw beautiful pictures and did not inquire as to their reality. * * * We fear that some of our engineers and many of our business men still sleep with handkerchiefs spread over their faces, dreaming of the greatness of Chicago as a maritime city."

The State of Illinois also appears to be rapidly changing its opinion as to the wisdom of its $20,000,000 appropriation to extend the Chicago Drainage Canal navigation and develop water-power. That appropriation was voted in the belief that if Illinois did that much, Uncle Sam would build all the rest of the 14-ft. deep waterway to New Orleans and that the water-power developed would pay for the whole enterprise. Now, however, the chance of Uncle Sam doing the rest appears remote. A private company has grabbed the water-power rights and doubt has arisen as to the value of the water-power when developed. The State of Illinois is having a sober second-thought about that twenty million dollars and may conclude to radically revise its program, at least, before proceeding with the work.

The city of Paris during the past fortnight, has been experiencing just such a calamity as is bound to come about once in so often to any city located upon a large sized river which is subject to torrential floods. Probably the damage done by the Seine has been much exaggerated by the reports which set the losses at hundreds of millions of dollars; yet those familiar with the damage wrought in recent years at Pittsburg, at Kansas City, at Topeka, at Williamsport, or at many other places in the United States will understand that after making all allowances for newspaper excesses, the actual damage will be of enormous amount.

The question that the layman brings forward at every such calamity is whether it is not within the powers of engineering to prevent such disastrous loss. And the answer to the question is, "certainly," provided the benefit is worth the cost. In the case of the Seine, for example, reservoirs might be provided in the watershed to store part of the flood flow, and the channel of the Seine through Paris might be made wider and the bridges over it higher, to give enlarged waterway. But in densely populated France, the land which storage reservoirs would withdraw from cultivation can ill be spared. To maintain reservoirs, moreover, you must keep land in use every year to save overflowing other lands once in fifty or a hundred years. It may be truer economy to let the floods continue.

Again, in Paris, the river is confined to its present channel by massive masonry walls. Possibly if the work were to be done anew today in the light of present knowledge, a wider channel would be adopted; but to change the dimensions of the present channel would destroy improvements costing a great many million dollars. Higher bridges and a broader channel would make the river more of an obstruction to traffic and thus would involve an increased expense every day for half a century, all to save a loss that comes probably only once in that time.

It should be understood, then, that all the engineer can do is to put the water which falls from the clouds *somewhere else*; and not without an exhaustive engineering investigation can it be determined which plan for disposing of flood waters is most economical.

And it may be well to emphasize here, too, that the work of engineers in river control is subject to a large factor of uncertainty. Take, for instance, the stage of highest water in the Mississippi River below Cairo. At present the height of the levees protecting many millions of dollars worth of valuable plantations and the city of New Orleans itself is fixed with reference to the highest water of past floods. But it is within the possibilities of the future that a flood may come out of the Ohio just in time to coincide with a flood in the Missouri and Upper Mississippi and that the crest of this combined flood wave may be added to the heavy flows in the tributaries from the Ozark Mountains and in the Cumberland. Such a flood might cause destruction in the lower Mississippi beyond all precedent.

We cite this only by way of illustration. The smaller rivers are subject to equally great floods from extraordinary local rainfalls. Witness the experience of Trenton and Paterson in New Jersey a few years ago, or the recent disasters at Monterey, Mexico, and along the San Pedro, Los Angeles and Salt Lake R. R. in southern Nevada.

It is not, therefore, within the resources of engineering to absolutely prevent flood disasters save under exceptional conditions, although a great deal can be done to reduce the risk and damage in years of ordinary high water. One lesson of the Paris floods, that may well be taken home by engineers, is the wisdom of taking special care of foundations for all structures located between high and low water. It is not to be expected that the lowlands adjacent to the rivers flowing through large cities will remain unbuilt upon; but when buildings are put up in such locations, the engineer will do well to ask himself whether the foundation he is putting in will be safe when deeply submerged and exposed to a strong current above. We doubt not that many engineers in Paris are now worrying over the condition of some of the foundations which have been submerged.

It may be remarked that the peculiar sewer system and underground rapid transit system of Paris makes the flood situation there one of unusual interest to the engineer. We have, therefore, given space in this issue to a paper by Mr. Geo. A. Soper in which these systems are described.

In defeating the proposition to buy out the Spring Valley Water Co., at the election on Jan. 14, the new labor-union Mayor of San Francisco, Mr. P. H. McCarthy, may have nullified the over-

whelming vote of 20 to 1 for the twin proposition to introduce a water-supply from the Tuolumne River, in the Sierra Mountains. We do not think it will quite come to that, but, as we stated in our issue of Jan. 20, the Spring Valley Water Co. is not likely to sit idly by and see the city establish a competing plant. Opposition on the part of the company may be fruitful of nothing but delay, but legal delays, at least, may be expected. The most hopeful alternative we can see is that the three principal parties concerned, that is to say, the public, the Spring Valley Water Co., and Mayor McCarthy, do the sensible thing and effect some compromise under which the city may yet buy the works of the company and thus avoid the great waste of money that would result if the existing distribution system of the company were duplicated by a new system.

It would be a pity to defeat or even to delay municipal ownership very long after the people have voted for it so emphatically as they did on Jan. 14. The Tuolumne River or Hetchy proposition carried by a vote of 20 to 1 (32,876 to 1,607). There was a large majority (22,059 to 11,724) in favor of buying out the Spring Valley Water Co., but it fell short by 1,234 votes of the necessary two-thirds. Certainly it ought to be possible to effect a compromise that would give the slight increase in votes necessary to bring the large actual majority up to the two-thirds required by law. Just how many hundred thousand or how many million dollars the company could afford to throw off its price of $35,000,000 for its works we do not pretend to say, but that a reduction sufficient to overcome two thousand votes would be profitable in the long run seems beyond question. The company should figure on that.

It is a serious matter for any city in these days to duplicate the works of a public-utility company, particularly when millions upon millions of dollars are involved. Such duplication is justified only when there is no other way of bringing a company to sell its works at a reasonable price. Is that the case at San Francisco?

An interesting side-light on the present municipal situation at San Francisco has been thrown by the new President of the Board of Works, Mr. Michael Casey, in the course of some comments on the proposed water-supply construction. President Casey, like Mayor McCarthy, gave prompt assurances, following the recent water-works election, that no time would be lost in getting at the introduction of the Tuolumne supply. He said further:

> It is not necessary to employ eastern engineers in this work. I favor building the Hetch-Hetchy plant with local talent. I will not go outside of the board of public works for engineers to do this work. It depends mostly on the handling of concrete, and that is no longer an experiment. I think Marsden Manson fully capable of handling the scientific end of the work.
>
> There may be considerable talk about the necessity of having competent engineers to install dams as large as will be necessary to impound the water. In my opinion, as a practical man, dams depend on the foundations, and I believe that all that is necessary is sinking until the proper foundations are found and then put in the dam.

Evidently, it will be a waste of time for "eastern engineers" to apply for positions on San Francisco's $35,000,000 water-works. We are glad to see that well-deserved confidence is placed in Mr. Marsden Manson, M. Am. Soc. C. E., for several years past city engineer of San Francisco. Perhaps he will aid Mr. Casey in learning that the better the engineer the more likely he may be to want to profit by the experience and judgment of an equally capable man, who will approach his problem with a mind free from obscuring fogs due to close application to local detail.

Certainly, Mr. Casey starts right when he tackles a dam proposition. Getting a proper foundation is the first thing, but even that is something more than a hole in the ground, and when the hole is dug some nice points may arise in filling it.

In view of all the enlightenment in sanitary matters of the past few years, it is surprising indeed to hear of a municipality which is still virtually drinking its own sewage. Instances of this sort were common enough a few years ago, but, by one means or another, it is reasonable to suppose that they are rare to-day. In the latter part of December, however, press despatches stated that a committee of the State Board of Health of Missouri, consisting of Dr. E. L. Robinson of Kansas City and Dr. J. A. B. Adcock of Warrensburg, had reported that a typhoid outbreak at Parkville, Mo., was due to the discharge of the sewage of the village into the Missouri River only about 65 ft. from the water-works intake. The first case of an outbreak of typhoid was reported in August, 1909, in the person of a citizen of the town who was using water from the source indicated. Within a subsequent period of not many weeks, 36 cases of typhoid developed among the students of Park College and three cases among the townspeople. For a time the water used at the college and in the town, it was stated, was boiled. In November, the boiling having been discontinued, 18 more cases developed among the students and 5 among the townspeople. An investigation seemed to exclude milk and all other sources than water as causes of the infection.

The incident seems to show the need of extending the powers and duties of the State Board of Health of Missouri so that it, like the boards of a number of other progressive states, will have general jurisdiction over water-supply and sewage disposal throughout the whole state.

The Parkville incident, outlined in the foregoing note, raises anew the question whether colleges and universities located in the smaller towns have a peculiar responsibility for the character of government of those municipalities. We limit the question to higher institutions of learning in the smaller places, because in these the teaching force often constitutes a very considerable percentage of the population as well as of the talent.

We are well aware of the traditional feeling of the "town" for the "gown," and there is plenty of evidence that interference of the professorial staff of the college or university in municipal affairs is sometimes resented. But that does not remove the undoubted obligation, as it seems to us, which is placed upon the college faculty in the smaller town.

One of the functions of our higher institutions of learning—as of our secondary schools, for that matter—is to fit young men and women to become efficient citizens. This involves not only a sense of civic responsibility, but the installation of the knowledge necessary to exercise that responsibility. As the old adage says, "Example is stronger than precept." We can conceive of nothing that would impress more strongly upon the student mind his responsibility and opportunities as regards the city and the state than to have brought to his attention throughout his college course the efficient service of his college faculty in helping to cure the many evils which afflict municipal administration. Such lessons might be particularly effective in connection with the sanitation of small towns, which is likely to be not only defective, but to have no one in particular to give it efficient supervision or control.

The notorious typhoid epidemic at Ithaca some years ago, the long-continued prevalence of typhoid fever and diarrheal diseases at Burlington, Vt., prior to the introduction of filtered water, afford instances of where those connected with higher institutions of learning seem to have failed to make any very great impress upon the sanitation of the cities in which Cornell University and the University of Vermont are located. In a smaller way, an outbreak of typhoid fever due to the infection of the public milk supply, which occurred at Palo Alto, Cal., the seat of Leland Stanford University, may be cited.

In saying what we have about the colleges and universities in the smaller places, we have not meant to absolve the educational institutions of our large cities from responsibility. In some respects the obligations resting upon the teaching force of these institutions is greater than those resting on small ones. As a rule, perhaps, the instructors in the larger colleges have done more to fulfil the obligations resting upon them than have the instructors in the smaller colleges, although we should hesitate to lay this down as a certainty. If we are not greatly mistaken, some of the members of the faculty of Dartmouth College at Hanover, N. H., and of Oberlin University at Oberlin, O., to name only two institutions, have done a great deal to improve certain branches of the municipal service in those small towns.

In considering the efficiency of machinery (and particularly pumping machinery), special attention is apt to be given to the results of trial runs or duty tests, which are made under careful supervision and under favorable conditions as to loading, etc. The results of such tests may be very creditable to the engine as a machine, and may show it to be very efficient and economical under these conditions. But the economy of which the engine is capable may never be approached in practice under the conditions of everyday handling by firemen and enginemen, varying qualities of coal, etc. It is perhaps not sufficiently recognized that it is the regular daily performance of an engine which determines its economy, and that a high efficiency under contract test is of no particular benefit unless it means also high efficiency in service. In another part of this issue we give particulars of some exceptionally high station duty performance by pumping engines at the Milwaukee water-works, this duty being very close to the duty obtained on the trial test. The figures were given first in a paper read at the last meeting of the American Water Works Association. In the discussion of this paper Mr. Geo. H. Benzenberg, M. Am. Soc. C. E., pointed out that such a result must be ascribed largely to the careful and faithful work of the pumping station staff, and that such results can only be obtained when these men are employed and retained on their ability to handle pumping machinery without regard to their rank as manipulators of any political machine.

In the same article are given the results of a high duty test on a pumping engine which so far as we recall breaks all records for high efficiency in the steam engine. This engine showed a duty of 183,115,000 ft.-lbs. per 1,000 lbs. of steam used of 153½ lbs. average pressure by gage. Some of our older readers may recall a series of papers by Prof. Jas. E. Denton, published in Engineering News in the first volume of 1890, which reviewed tests on the famous pumping engine at Pawtucket, Mass., built by Geo. H. Corliss in 1879. The Pawtucket engine in tests made by Prof. Denton 20 years ago, showed a duty of 145,041,000 ft.-lbs. per 1,000 lbs. of steam at 128 lbs. pressure. It will be seen that the advance of steam engineering practice in the 30 years from 1879 to 1909, has raised the duty record of high-duty pumping engines about 38,000,000 ft.-lbs. In terms of heat, Prof. Denton's tests on the Pawtucket engine 20 years ago showed a heat consumption by the engine alone of 234.4 B. T. U. per horse-power minute. The Albany engine tested this year gave a horse-power minute with only 193 B. T. U.

Three million feet of prime Oregon pine are being 'butchered to make a Southern California holiday' or, more explicitly, are being used in the construction of an automobile race track at Los Angeles a mile long and 75 ft. wide, with the curves "banked" to a height of 25 ft. The projectors of this modern race track claim that it will permit of higher speed than any existing race track with paved surface. They mention nothing, however, of the fire risk in connection with such a huge structure when baked dry under fierce sun and soaked with oil from the motors speeding over it. All told it seems a pity that these three million feet of choice timber were not left in the forests or used in some structure likely to have longer life and to produce a greater measure of public benefit.

The Improvement of Living Conditions in Construction Camps.

Many pages of the January 1 number of "The Survey" are given over to an account of an investigation by two women members of the New York State Immigration Commission into the construction camps along the line of the New York State Barge Canal and the new aqueduct of the City of New York. This investigation took the form of a two weeks' automobile tour through the districts covered by the work and a personal inspection of most of the camps along the way, together with a study of the provisions of the contract between state or city and contractor as regards the treatment of the laborer in his camp and the sanitary protection of that camp.

The report is designed to expose the deplorable conditions under which the unskilled labor on these two great works is compelled to live. It shows that the contracts on the State Barge Canal contain no provisions regarding the treatment of labor and as a consequence the camps are in a condition extremely offensive to the senses of those not familiar with the conditions common on works employing large amounts of unskilled labor. Padronism exists in the most extreme forms, liquor selling, both licensed and unlicensed, goes on in nearly every camp, lodging-houses are without the most elementary sanitary appliances and so crowded as to make the mule stalls seem capacious, and food for the men is a minor consideration, either as to quality or quantity.

On the aqueduct work conditions are much better, largely because the contracts prescribe certain regulations to ensure proper sanitary conditions in the camps. On most of the sections the contractors have cooperated with the city in constructing and maintaining the best possible camps and have even gone further and provided schools for the children and amusements for the men and their families. The main difficulty has been that the city has no control outside of the limited areas of the aqueduct itself and in some instances the adjoining townships, profiting by the taxes gained, have allowed all kinds of disorderly houses on the outskirts of the camp, which largely nullify all the good produced by the proper administration of the camp itself.

These facts are essentially the same as outlined in the report on the same subject by the State Bureau of Factory Inspection (Eng. News, Aug. 5, 1909, p. 154), except that the authors of the magazine story, failing to recognize the standard of living of the class of men subjected to the conditions observed, have visited upon those men a deal of misplaced sympathy. No man should be compelled to live in the squalid, unhealthy fashion noted in the worst of the camps, it is true; but it is likewise true that the ordinary comforts of the skilled American workman are undreamed of luxuries to the foreign-born unskilled laborer, to whom the poorest of the camps is as pleasant as the home he has left.

For this the Factory Inspector's report makes allowance. Thus we read that despite efforts to provide the alien laborer with bathing facilities, he "generally remains among the great unwashed" and that with all the lack of sanitation and poor pay, "little sickness exists among the men and they are often able to take a vacation in their foreign homes during the winter months." This same report states that of the 16 camps on the canal work, one is "poor," 4 "fair," 10 "good," and one "excellent," a very different record from the almost universally deplorable conditions reported by the members of the Immigration Commission.

It is probable, then, that though conditions are bad enough to demand some reform, the experience of the investigators from the Immigration Commission with foreign immigrants living in cities has led them to magnify the effect of the ill-kept camps upon the sort of men working in them. Conditions in a construction camp must of necessity be rough, the work that the men are doing and the nature of the men themselves do not conduce to gentility and, as Kipling has it, "Single men in barracks don't grow into plaster saints." These facts should be appreciated in such an investigation, particularly if its results are to be used as a basis for reform. It would seem, then, that a much more valuable investigation into the construction camps would be by a committee of contractors and engineers, who understand the kind of men they are working with, the method of their normal living and the degree of sanitary reformation their habits will stand. If the Immigration Bureau or the State Department of Labor desire to get at a more reasonable basis of camp reform we would recommend their appointing such a committee.

Bearing in mind these limitations, there is ample opportunity for the bettering of ordinary camp conditions. There are at least three reasons to recommend such a reform: the desirability of uplifting the lower class of immigrants, the necessity of protecting the health of the communities in which the camps are located and the certainty of an increased efficiency from men living in clean, wholesome camps. The first of these appeals to everyone, but unfortunately the appeal is not very emphatic. The making of cleaner, healthier and more moral citizens out of these newly landed men is so little appreciated and the reward so indirect that few can be induced to undertake the work. Just how much of this education, mainly a sanitary education it would be, can be thrust upon a contractor and how much must be assumed by the state enters here also, for the contractor cannot be expected to assume the burden of making his workmen good citizens.

The second reason is of local interest only, but when a community has suffered as Ithaca did in the typhoid epidemic of 1903 it may think it worth while to investigate and to regulate construction camp sanitation around the source of its water supply. The final reason is aimed at the contractor. He will be economically justified in spending just as much in improving his camps as the increased efficiency of his men will pay for. Observation of some of the better camps, such as those of the McArthur-Winston Co., at Ashokan, in New York, and of the McCall Ferry Power Co. on the Susquehanna in Pennsylvania, will show that this justified expenditure is no small amount. But, our sociologist friends to the contrary notwithstanding, in these competitive times the contractor cannot be expected to furbish up his camp for unappreciative laborers beyond the point where such improvements bring in demonstrable returns.

That contractors themselves are taking more interest in the matter is evident from the number of model camps that have been built on the big construction jobs of the last five years. The contracts of the city of New York requiring proper attention to the treatment of the laboring force is an indication of governmental solicitude for the men and the communities where they work. There are, then, signs that improvement is going on at a fair rate of progress. It is to be hoped that it will not be retarded by a false sentimentalism regarding hardy men who are doing men's work under conditions which, in the very nature of the men and of the work, can never be expected to reach the sanitary and social perfection of a permanent community.

LETTERS TO THE EDITOR.

Ice Stoppages of Water-Works Intakes.

Sir: In your issue of Dec. 16, 1909, Mr. E. E. Lochridge, Assoc. M. Am. Soc. C. E., gives a description of an interesting case of a brief water shortage at Springfield, Mass., caused by a mass of very thin and fine ice crystals filling quite a space back of a ¼-in. mesh screen, inserted to keep back leaves, fish, etc. The friction of the water passing through this retained mass of ice crystals had caused the water pressure in the water office to drop, apparently within less than 12 hrs., from 120 to 50 lbs. per sq. in. The temperature of the air had dropped severely during those 12 hrs., leaving an ice covering on the water sufficently firm to hold a man.

Similar cases are not rare, as you remark. They have occurred frequently on the Great Lakes and in the St. Lawrence River. No mention is made by Mr. Lochridge of any remedy to prevent such occurrences, and, concluding from a recent inquiry received, there still seems to be a doubt here and there as to what the remedy would be.

Over thirty years ago Toronto placed a submerged intake in Lake Ontario through which it received its water supply. The screen or grating was made of wooden slats, because, as the engineer told me, wood is a non-conductor of heat and prevents the passing ice spicules from holding fast, freezing on and subsequently clogging. He also made the screen area sufficiently large to reduce the entrance velocity to but a few inches per second. The intake has never been clogged by ice, as I but recently understood.

The Canadian engineer's reasons appeared to me to be very sound and where applicable I have repeatedly quoted this case and advised accordingly. There are instances, however, not only where wood as a material cannot be used, but also where the screen in a particular case must have a finer mesh than wood permits; in short, metal screens are often necessary.

Since electricity is extensively used in cities we have now a means of providing, sometimes at very little expense, means for a current to be passed through the wires or bars, when anchor ice is forming, sufficient to raise and maintain their temperature well above 32° F., which will cause the spicules at their surface to melt when striking the metal, and thus slip through and not clog the screen.

Respectfully yours,

Rudolph Hering.

170 Broadway, New York City, Jan. 20, 1910.

[The use of both electric and steam heating for preventing trouble from ice at power-plant intakes is described in "Ice Formation," a book by Prof. Howard T. Barnes, of McGill University, Montreal, P. Q., published in 1906.—Ed.]

The Yield of Two Ponds Without Visible Outlet; Water Supply of Plymouth, Mass.

Sir: I am enclosing a table showing my estimate of the probable average daily yield of our drainage area, which contains about 1½ sq. mi. Included in this area are two ponds, Great and Little South Ponds. Great South Pond has an area of about 200 acres and Little South Pond of about 65 acres.

These ponds have no apparent inlet or outlet and appear to be large open wells in gravelly soil. I have made careful surveys of both of these ponds on the ice. From soundings which were taken at the same time the surveys were made I have been able to compute with a considerable degree of accuracy the storage volume in each of these ponds for each foot in depth. These two ponds are connected by an open culvert which permits of a free passage of water between them and the water supply for our town is taken directly from Little South Pond.

Part of our supply is the gravity system and on the gravity pipe line is a Venturi meter, which enables us to measure our total gravity flow. The balance of the supply for the town is pumped. We keep daily records of the amount of water which passes through our Venturi meter and the amount of water which we pump. Also, we take weekly readings on the height of our ponds.

The accompanying table shows the records for about two and one-half years, since our Venturi meter has been installed. The first column in this table gives the

AVERAGE DAILY YIELD OF DRAINAGE AREA OF GREAT AND LITTLE SOUTH PONDS WATER-SUPPLY OF PLYMOUTH, MASS.

(In millions of gallons.)

Month.	Consumption.	Inc. or dec. in storage.	Av. dy. yield, month	Yield for year.	Rainfall ins.
June, 1907...	37.1	—20.8	580	....	2.70
July, 1907...	43.1	—42.8	...	....	1.10
Aug., 1907...	44.9	—19.0	835	....	1.82
Sept., 1907...	35.4	+ 4.0	1.310	....	11.16
Oct., 1907...	32.6	—10.0	730	....	2.91
Nov., 1907...	31.7	+16.6	1.610	....	6.82
Dec., 1907...	32.0	+46.8	2.540	1.087	6.90
Jan., 1908...	34.6	+32.3	2.160	....	3.78
Feb., 1908...	38 0	+34.6	2.600	....	4.37
Mar., 1908...	33.8	+31.0	2.090	....	3.95
Apr., 1908...	33.6	— 1.2	1.090	....	2.48
May, 1908...	38.1	—13.0	810	....	2.08
June, 1908...	45.8	—31.5	475	....	2.30
July, 1908...	53.7	—24.1	955	....	3.87
Aug., 1908...	47.3	—32.3	480	....	4.41
Sept., 1908...	36 9	—21.0	530	....	1.61
Oct., 1908...	30.7	+15.2	1.480	....	10.19
Nov., 1908 ..	26.4	—14.8	385	....	1.53
Dec., 1908...	31.1	+ 1.1	1,040	1.174	4.28
Jan., 1909...	34.2	+24.8	1.900	....	5.44
Feb., 1909...	33.4	+40.2	2.630	....	6.18
Mar., 1909...	31.0	+13.8	1.445	....	3.74
Apr., 1909...	29.8	+53.5	2.780	....	6.41
May, 1909...	35.2	0.0	1.135	....	3.51
June, 1909...	44.1	—28.8	510	....	3.06
July, 1909...	53.3	—48.7	150	....	1.83
Aug., 1909...	51.5	—51.8	...	....	2.44
Sept., 1909...	42.6	—12.0	1.000	....	4.95
Oct., 1909...	38.9	—33.0	190	....	2.23
Nov., 1909...	33.7	+46.5	2.670	....	8.15
Dec., 1909...	35.2	0.0	1.135	1.295	3.94

month during which the record was taken, the second column shows our total consumption in millions of gallons, which is a combination for that month of the amount which went through our Venturi metar and the amount pumped. The next column shows the increase or decrease in pond storage for that same month. When our pond storage has been negative I have assumed that the difference between that and our total consumption was the net yield of our drainage area for that month and where our pond storage was positive or showed a gain I have assumed that the sum of that amount with our consumption for that month was the total yield for that month. This method of computation neglects evaporation entirely.

Does this method of computation give a fairly accurate method of determining the net yield from our drainage area, assuming that our Venturi meter, the records from our pumping engine and our computation on the increase or decrease in pond storage were accurate?

Yours very truly,

Arthur S. Blackmer,
Superintendent of Water-Works.

Plymouth, Mass., Jan. 18, 1910.

[The question raised by our correspondent hardly seems to need discussion in our columns, but assuming that the figures given in his table are approximately correct, they are an interesting contribution to the yield of underground sources of water-supply.

Obviously, if the monthly yields are to be used to compute yearly totals then instead of entering zero yields minus quantities should be used whenever decrease in storage exceeds consumption for the month.

Perhaps we hardly need say that this method of computation does not show the quantities of water reaching the ponds but merely the volumes available for draft during each month, under the then-prevailing conditions of total surface area and evaporation and total bottom area and seepage. As to seepage losses, these would of course be absent if the ponds are in a perfect basin, which has neither overflow points in its rim nor previous strata anywhere in its bottom or sides.—Ed.]

Solution of the Crossover with Tapered Curves.

Sir: I wish to thank you for your solution of the crossover problem (Eng. News, Dec. 30, 1909, p. 731), which appeared in connection with Mr. W. C. Willard's article on the Southern Pacific Taper Curves. I observe that the solution calls for the finding of absolute values for $\triangle_1$ and $\triangle_2$ before it is possible to work out the traverse for the length and bearing of the long chord. But when $\triangle_1$ and $\triangle_2$ are once found, the traverse is useless, as a simple calculation of the semi-tangents of the curves gives everything else that is necessary.

Mr. Willard neglects in his article to illustrate the use of the values D and t, as given in the Taper Curve tables. These quantities are very important in the application of these tables to various problems, and their proper use goes far toward simplifying a required solution, as for example in the case of the crossover problem. I take the liberty of sending you the following solution of this problem, because it serves to illustrate the use of these values D and t in many cases of a similar nature.

Assuming data as taken in your example:

Length of tangent, 400 ft.

Curve 1, 4° curve, $R_1 = 1432.47$ ft. (for 50-ft. chords).

Curve 2, 5° curve, $R_2 = 1146.01$ ft. (for 50-ft. chords).

Both curves spirailed by taper table 2.

Total curvature in tapers is 3° 36′ and 6° 00′, respectively (from table).

Distance between parallel tangents, 150 ft.

From Taper Table 2 we find $D_1 = 1432.85$ ft., $t_1 = 45$ ft.; $D_2 = 1146.78$ ft.; $t_2 = 60$ ft. Using these values in the right triangle $O_1 N O_2$ (see diagram herewith), we obtain $O_1N = D_1 + D_2 = 2{,}579.63$ ft. and $O_2N = 400 + t_1 + t_2 = 505$ ft. Then $\tan x = \frac{505}{2{,}579.63}$ and $x = 11° 04\frac{1}{2}'$

$O_1 + O_2 = (D_1 + D_2)$ Sec. $x = 2{,}628.59$ ft.

In right triangle $O_1 MO_2$, $O_1M = D_1 + D_2 - 150 = 2{,}429.63$ ft.

$\cos y = \frac{O_1 M}{O_1 O_2} = \frac{2{,}429.63}{2{,}628.59}$ and $y = 22° 26'$.

$\triangle_1 = 22° 26' - (11° 04\frac{1}{2}' + 3° 36') = 7° 45\frac{1}{2}'$.

$\triangle_2 = 22° 26' - (11° 04\frac{1}{2}' + 6° 00') = 5° 21\frac{1}{2}'$.

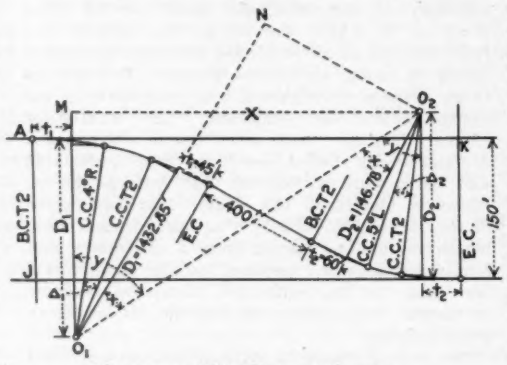
$X = O_1 M \tan y$ and $A K = X + t_1 + t_2$. With these data the crossover is easily laid out and stationed.

H. M. Lull.

East Auburn, Cal., Jan. 4, 1910.

Sir: Further in regard to the tapered reverse curve between parallel tangents, or the crossover problem of Mr. Willard's article of Oct. 28, 1909, solution of which was given by Engineering News Dec. 30, 1909: The writer fails to recognize the Engineering News' solution as being effected through the application of the traverse method, which method invariably involves only simple trigonometric and geometrical relations, and is the method used by Mr. Willard in the other problems of his article. The editor admitting that his solution is "tedious and clumsy," the writer would term it a complex trigonometrical solution involving trigonometrical equations rarely used in railway engineering outside of a college classroom. However it must be admitted that the editor's solution gives the correct result, for the writer checked the problem as outlined in a few minutes time [By the same method as given above by Mr. Lull.—Ed.]

In solving many of the problems involving the Southern Pacific Co. Taper Curves, it has been the experience of the writer that a knowledge of the uses of the functions "d," "D" and "t" renders the solution of the problems quite as easy as those involving only the common circular curves—a strong point in favor of the



Crossover With Tapered Curves.

Taper over some of the other forms of easement curves, because complete tables of the functions as well as the deflections are always at hand. All transit books issued by the engineering department of the Southern Pacific Co. are provided with copies of the Taper Tables, the same being glued to the cover and first flyleaf.

In regard to the application of the ordinary traverse method to railway line or other problems, there are no problems that can be solved that will not admit of solution by the simple ordinary traverse method, but not necessarily in one closure. Many problems can be resolved into two parts to be solved in a logical order, and the above crossover problem is an example of that kind. Had Mr. Willard so treated it in his article, the writer would have had no criticism to offer beyond stating that the problem was not one of a practical nature.

C. M. Kurtz.

234 Iowa St., San Francisco, Cal., Jan. 12, 1910.

Notes and Queries.

A correction of the report, published in our issue of Jan. 20, 1910, p. 82, that a small railway bridge collapsed near Wister, Okla., under a westbound freight train on the Chicago, Rock Island & Pacific Ry. has been received from Mr. F. W. Fatherson, District Engineer of the Rock Island Lines at Little Rock, Ark. Mr. Fatherson describes what actually took place as follows:

Ten cars, one of which contained chemicals and three oil, were derailed at Bridge No. 3120, ten miles west of Wister, Okla. The wreckage caught fire and nine cars, with contents, were destroyed. The ties on Bridge 3120, an 80-ft. deck plate-girder bridge, were also burned. There was no loss of life, no collapsed bridge and trains were running as usual a few hours after the accident.

The accident occurred Jan. 12.

RAILWAY ACCIDENTS IN PENNSYLVANIA in 1909, according to the report of the State Railroad Commission, caused the death of 1,262 persons and injured 13,163 others. Of those killed, 592 were trespassers on the lines of steam railways, and 864 such trespassers were injured. Sixty-eight persons were killed and 290 injured during the year at grade crossings. No accidents occurred on 84 of the steam railways and 47 of the electric lines in the State.

FOREST FIRE LOSSES in California during 1909 are placed at $1,000,000 by State Forester Lull. On merchantable timber alone the loss as given was only $100,000. To this the estimates add $400,000 for damage to young growths and "injuries to watersheds through the removal of water-conserving brush and timber." Damages to grass, grain, fences and buildings are placed at $500,000. The total burned area of 357,000 acres included 77,000 acres of forest, 88,000 acres of grass, and 192,000 acres of brush.

Preliminary Report of the United States National Waterways Commission.

The National Waterways Commission, composed of twelve members of the Senate and House of Representatives, was created by act of Congress March 3, 1909, to investigate questions pertaining to water transportation and the improvement of waterways, and to make recommendations to Congress.

The commission has held numerous meetings, both in the United States and Europe. Seven of the twelve members took a somewhat extended tour for the examination of European waterways from August to October last. In addition, a majority of the members of the commission examined the Mississippi River from St. Paul to New Orleans in November, 1909, and some of them also, during the same month, inspected the Missouri River from Kansas City to its mouth, and the Illinois River from its lower portion up to the head of navigation. It may be added that the commission includes in its membership Senators or Representatives who at different times during the last ten years have examined nearly all of the waterways of the United States. Consequently its members are enabled to bring to the consideration of the problem a very considerable familiarity with the waterways both of the United States and of Europe as well.

The commission has been aided in the course of its investigations by officials detailed from the War and Navy departments, and has obtained the assistance of other experts in waterway transportation. In the framing of this report, especial aid has been rendered by Rear-Admiral C. S. Sperry, of the Navy Department; Col. W. H. Bixby, and Maj. F. A. Mahan, retired, of the Corps of Engineers, U. S. Army; and also by Prof. Frank H. Dixon, of Dartmouth College, and Mr. E. O. Merchant, of Columbia University.

The commission now presents its preliminary report. In reaching conclusions upon the specific items set forth in the statute creating the commission, it has been deemed necessary to report also upon related topics, such, for illustration, as water power and bank protection, which are assuming prominence in connection with river and harbor legislation.

It has been impossible to give such elaborate and careful investigation as the members desire to all of the questions pertaining to waterway improvement. In a later report it is intended that further recommendations will be made, and such additional material as may be collected will be filed with Congress. The conclusions presented express the unanimous opinion of all the members of the commission, except in one instance.*

1.—The Reasons for Decline in Inland Waterway Transportation, Together with Suggested Remedies Therefor, and the Relation Between Waterway and Railway Transportation.

The commission has had under consideration the manifest decrease in water-borne traffic on a majority of the rivers and inland waterways of the country.† On many there has been an absolute decrease, while on others the falling off has been merely relative. In these latter cases, although the aggregate traffic by rail and water has been greatly multiplied, the proportional share carried by water has very noticeably diminished.

Perhaps the most striking illustration of this is the traffic of the Erie Canal. In 1880 this canal carried between Buffalo and New York 4,608,651 tons, or 18% of the total traffic, while in 1906 (the latest year for which statistics are available) the canal carried only 2,385,491 tons, or 3% of the total traffic, as against 78,703,315 tons transported by the New York Central and Erie railways. Not only has the actual traffic on the canal decreased nearly 50% since 1880, but the relative amount carried by the canal, as compared with the two railroads, has fallen off from 18% to 3%.

Likewise, on as important a river as the Hudson, the local river commerce, exclusive of what comes through the Erie Canal, has shown a considerable decline. For the section of river between Coxsackie and the state dam at Troy there has been a falling off from 4,045,895 tons in 1898 to 2,945,921 tons in 1908. On a number of southern rivers also, such as the Altamaha, Tombigbee, and Pearl, there has been a marked decline in river traffic.

Quite as striking is the decrease in traffic on the Mississippi River and most of its tributaries. The figures in Table I. emphasize this fact:

*The question whether the Interstate Commerce Commission should have power to prescribe minimum railway rates to prevent a railway destroying competition on a waterway.

†The most reliable statistics relating to water-borne traffic are to be found in the Census Report on Transportation by Water, 1906, published in 1908; Report of the Commissioner of Corporations on Transportation by Water in the United States, 1909; and the annual reports of the Chief of Engineers to and including 1909. The commission has also examined numerous reports of chambers of commerce and trade bodies. See also Preliminary Report, Inland Waterways Commission (1908), pages 35 to 176.

TABLE I.—FREIGHT SHIPMENTS, MISSISSIPPI RIVER SYSTEM, FOR 1889 AND 1906.
[Compiled from Census Report, Transportation by Water, 1906, p. 181.]

	1906.					1889—	Change since 1889.	
	Self-propellers. Tons.	Per cent.	Barges and tows. Tons.	Per cent.	Total tons.	total tons.	Gain. P. ct.	Loss. P. ct.
Upper Mississippi	153,932	25.8	441,953	74.2	*595,885	*3,947,304	..	85
Illinois River	32,764	31.0	73,062	69.0	105,826	180,264	..	41
Missouri River	84,790	8.2	952,269	91.8	1,037,059		..	
Other tributaries above St. Louis	1,876	9.7	17,455	90.3	19,331	2,132,820	..	42
Total upper river system	273,362	15.5	1,484,739	84.5	1,758,101	6,260,448	..	72
Ohio River system	1,246,437	8.2	13,980,368	91.8	15,226,805	15,796,968	..	3
Lower Mississippi system	835,587	32.8	1,710,600	67.2	2,546,187	6,232,087	..	59
Total Mississippi system	2,355,386	12.1	17,175,707	87.9	19,531,093	28,289,503	..	31

*These figures do not include ferry traffic at St. Louis.

Other tables furnished by the Department of Commerce and Labor, classifying these shipments by commodities, show that the main items of decrease have been logs and lumber, ice, grain, coal, iron ore, and general merchandise on the upper Mississippi River system, and grain, lumber, cotton, and general merchandise on the lower Mississippi River system. The decline in the rafting of logs and lumber is responsible for a considerable share of the decrease shown.

On the other hand, the traffic on the Great Lakes has increased enormously. The total commerce passing through the Sault Ste. Marie Canals, where very accurate statistics are collected, amounted to 3,256,628 tons for the season of 1885, 21,234,664 tons for 1898, while for 1908 it had increased to 41,390,557 tons, and for 1909 to 57,895,149 tons. Increased channel depth and lock facilities have been provided from time to time to meet the increasing traffic. It should be stated, however, that the Great Lakes are in a class by themselves. Likewise on some rivers, such as the Monongahela, the Kanawha, and a number of minor streams, the traffic has shown a considerable increase. On the Ohio River the aggregate tonnage has been well maintained, also on portions of the Tennessee it has shown some increase. A notable feature of the traffic upon some rivers has been the development of transportation for short distances, including ferry traffic.

The most frequent argument for river transportation has been that for coarser freights over long distances water transportation afforded very great advantages. There can be little question of the general accuracy of this statement. A boat or barge floating in the water is readily moved and at low speeds requires far less power than the movement of a railway car or other receptacle for freight used on land. The general statement has been made and widely accepted that with an equal expenditure of power about five times as much freight can be handled by water as by rail. The expense of equipping a transportation line, at least so far as the boats are concerned, is but trivial in comparison with that of constructing a railway. River transportation again has a decided advantage in that the waters are free, and anyone having the requisite capital and ability can engage in the business. This tends to create competition and to prevent monopoly.

Indeed, it may be asserted as a general proposition that in any highly advanced country it is extremely desirable that an abundance of transportation facilities be furnished and that means be afforded for the carriage of freight not only by rail, but by water as well. It is a matter of common occurrence that in years of great crops or unusual prosperity the railways of the country have been unable to provide for the prompt and efficient performance of their duties as common carriers. The existence of this condition affords an independent argument for the development of transportation routes by water, even in localities where shippers mainly depend upon railways.

It has been the aim of the commission to find the explanation of the marked tendencies which have become manifest in the diminished use of most of the inland waterways of the country, and, if possible, to point out certain remedies.

It is the opinion of the commission that the most important factor in the decrease of water-borne traffic alongside of and contemporaneously with the great increase in railway traffic is due to the relations existing between these two great agencies for transportation.

The many advantages which a railway has in competition with a water route may be grouped into two general classes.

1. Those inherent or fundamental advantages which are based upon permanent conditions.

The first and most important of these is the wider area of distribution available to railways. A railroad line can be constructed in any direction to any part of the country except the portions which are admittedly inaccessible, while the line of a river is fixed by nature in a single direction. Railroads are more readily adaptable to the newly arising and ever-shifting demands of producing areas and of markets. In providing for the receipt and delivery of freight at factories or warehouses, branch lines or switches can be constructed. Railroads can reach all cities and towns alike, whether located upon the water or not, while obviously boats or barges can not be used except for the receipt and delivery of freight or passengers from or to localities upon waterways. The rapid growth of inland cities not located upon waterways, many of which have attained very considerable size, emphasizes the possibility of development where the dependence for transportation facilities must be upon railroads alone. Notable illustrations of such prominent centers are Birmingham, Ala.; Atlanta, Ga.; Columbus, Ohio; Indianapolis, Ind.; Denver, Colo.; and a great number of cities and towns which are not provided with facilities for water-borne traffic.

A second advantage of the railways, which can be counted as belonging to this class, lies in the increasing importance of terminals and the necessity for facilities for the prompt and economical loading and unloading of freight. The cost of hauling freight, as compared with the handling or delivery at terminal points, has experienced a great change in the last forty years. The cost of hauling has very materially decreased, while the cost of handling and the expenses connected with terminal facilities, though diminished in many ways, have not decreased accordingly.

A third advantage in this class is intimately associated with the preceding, and arises from the readier transfer of traffic from one railway to another, as compared with transfer from water to land or land to water. This includes not only physical transfer of traffic, but the through haul of cars without break of bulk and a thorough organization for through billing over various roads, with facilities for easy settlement of joint accounts of the cooperating railways. In this connection may be mentioned a physical disadvantage of rivers, due to the very considerable oscillation in their levels. This fact makes it more difficult to provide convenient and adequate loading machinery and renders the receipt and shipment of freight proportionately more expensive. The variation in the Ohio River at Cincinnati is over 60 ft.; that of the Mississippi at Grafton, Ill., below the mouth of the Illinois River, is 29.6 ft.; at St. Louis, 43.92 ft.; below Cairo and the mouth of the Ohio River, 45.6 ft.; between Memphis and Helena, Ark., 54.75 ft.; at Vicksburg, Miss., 58.98 ft.; and at New Orleans, La., 21.02 ft.

Another consideration is that railways, as a rule, make a higher speed per hour and the distance to be traversed between terminals is usually shorter by rail. Furthermore, the railway is more reliable in its schedules. It should, however, be stated that on certain water routes in this country, especially in seasons of traffic congestion, freight is quite as promptly delivered, and in many instances more promptly, than on railways.

2. Those advantages pertaining to railways which may be deemed artificial or temporary. These are due to conditions not necessarily permanent in their nature.

The first and most important of these is the right of the railway to charge lower rates between points where their line is in competition with water routes.

Section 4 of the Act to Regulate Interstate Commerce contains the following provision:

That it shall be unlawful for any common carrier subject to the provisions of this act to charge or receive any greater compensation in the aggregate for the transportation of passengers or of like kind of property, under substantially similar circumstances and conditions, for a shorter than for a longer distance over the same line, in the same direction, the shorter being included within the longer distance.

The words "under substantially similar circumstances and conditions" found in this section have been interpreted to mean that the existence of actual water competition constitutes a circumstance sufficiently dissimilar to relieve the carrier from the operation of the law. Under this interpretation the cutting of rates, where water competition exists, has been carried to an almost unlimited extent. It is now a question whether the right to lower competitive rates has not been exercised to an extent much in excess of what was intended when the act was passed, and, it may be added, to a degree quite inconsistent with the most salutary policy for the commercial and industrial interests of the country.

A second of these artificial or temporary advantages of the railroads comes from the power to acquire steamboat lines or enter into agreements with them for the purpose of stifling water-borne traffic, either by operating the steamboat lines or by discontinuing their use upon competitive routes. In both methods, namely, in the acquisition and operation of steamboat lines in such a manner as not to compete with railways, and in removing them entirely from the field of competition, the railway companies of the country have been very active.

A third advantage arises from the refusal to pro-rate on through routes where naturally freight would be carried part of the way by rail and part by water. In many cases the route which apparently is the natural one, would be by water for three-fourths or more of the distance, yet the charge for the remaining railway haul is so considerable as to render carriage for the longer haul by water unprofitable.

A fourth advantage of the railways, in this class, is the far greater attention given to provision for warehouses, terminals, and the equipment for handling freight. On many of the waterways very little if any progress has been made during the last fifty years in furnishing modern facilities for the storage or handling of traffic. In each of a considerable number of cities located upon rivers and canals in Germany the members of the commission during their recent inspection trip saw a larger investment for terminals and for the storage of freight and handling of boats than exists on the whole of the Mississippi River above New Orleans.

It is to be noted that in localities where water-borne traffic has increased, as on the Great Lakes, careful and elaborate provision has been made for the handling of freight in the most economical manner. It is not, in the opinion of the commission, difficult to explain the remarkable increase in this locality. Upon the Great Lakes there is a demand for the shipment of freight unsurpassed anywhere. The great iron-ore mines of the upper lakes and the very large quantities of grain awaiting shipment toward the more populous regions of the Atlantic seaboard and for export to Europe, as well as the quantities of lumber, which, though greatly diminished, are nevertheless considerable, afford cargoes for the downward trip, while the great demand for coal in the territory tributary to the upper lakes and the great supplies near to Lake Erie afford a return cargo which, though relatively much less in volume, is still very large. The equipment for the loading and unloading of freight at terminal points is more advanced than anywhere else in the world. The boats are constructed with a view to utilizing space, so that a given tonnage will carry the greatest possible load, and those carrying the larger part of the traffic are specially constructed with a view to rapid loading and unloading of their cargoes. On the Great Lakes there are, moreover, channels of 20 ft. on through routes, with an equal depth in the large harbors. Notwithstanding the immense traffic on these lakes, it is, however, a noticeable fact that the quantity of general merchandise or package freight has not kept pace with the far more rapidly increasing traffic in the staple articles—iron ore, coal, grain, and lumber. It is estimated that not more than 5% of the total traffic on the lakes is made up of materials other than those mentioned. The traffic in these staples passing through the Sault Ste. Marie Canal in 1907 included 97½% of the total.

On the Monongahela River, which, next to the Great Lakes, affords the most striking illustration of the growth of inland water-borne traffic, coal mines are located at or very near to the river, and these supply a part of the almost unlimited quantity demanded for fuel in the mills and furnaces in or near to Pittsburg. This coal is readily loaded from the mines into boats or barges and from them directly discharged to the mills or furnaces where required. About one-third of the coal moves beyond Pittsburg to points on the Ohio and Mississippi rivers.

On a number of minor streams, such as the tributaries of the Delaware, traffic has been well maintained by established boat lines which have been in existence for a very long time. One great advantage possessed by these streams is the possibility of delivering freight to towns not provided with railway transportation. Also, in some instances, there is a very considerable saving in distance.

In still another class, traffic, though not so well maintained, continues to be large, as on the Penobscot and Kennebec rivers, to points upon which freight and passengers are carried by boats running from Portland or Boston, also on the Connecticut River, where the city of Hartford has a daily line to New York City. Such water routes involve a combination of river and coastwise traffic and are frequently able to provide for the delivery of freight more promptly than by rail.

It has repeatedly been urged that rivers should be improved because of the tendency of such improvements to lower railroad rates. This tendency can not be denied. It is very manifest in every portion of the country where rivers have been improved; and so considerable has been the effect that it has frequently been argued that even if a river channel should not be used at all, it would be profitable to expend money upon it solely for the effect upon rail rates. The commission, while fully recognizing this fact, can not indorse this as a desirable policy to adopt. It rests, in the first instance, upon the transparent fallacy that the railways constitute an intrenched and uncontrollable monopoly which can not be reached by legislation or other orderly and legal methods; that the only way in which to compel

them to lower rates is by the expenditure of large sums of money in the improvement of channels, which are to remain wholly or partially unused. National or state legislation is certainly sufficient, and should be resorted to for securing proper reductions in railroad freight rates. Again, the subject of transportation should be considered as a great economic problem. The cost of facilities for carrying freight, whether borne by the Federal Government or by private capital, is a burden upon the resources of the country. While the tendency of waterway improvements to lower freight rates is an important element to be considered, the fundamental criterion should be whether a railway or waterway, when constructed or improved, will be a profitable investment of capital.

As regards remedies to overcome the second general class of advantages of railways over waterways, those designated as artificial or temporary, the commission has considered a great variety of propositions. It has been brought to our attention that in a number of instances railways have temporarily reduced rates and continued them upon a lower basis until competing water lines have been driven out of business. The commission would recommend that in such cases, when a rate is once reduced by a railway, it should not be permitted to raise the same unless, after hearing by the Interstate Commerce Commission, or other competent body, it should be found that such proposed increase rests upon changed conditions other than the elimination or decrease of water competition.

The most essential requirement for the rehabilitation of water traffic is, in the opinion of the commission, the establishment of harmonious relations between railway and water lines. It is quite as important that there should be cooperation between them as that greater depth of channels should be secured. A study of the water routes which are found to be profitable in the United States discloses the fact that in practically every case the boats upon them are operated in connection and in harmony with railway lines, and, on the other hand, many railways utilize boat lines either actually owned by, or operated in harmony with, them to their very great benefit. It thus appears that to an extent this cooperation already exists, and the transportation facilities of the country will, as we believe, be still further promoted by compelling joint rates and pro-rating agreements; also by requiring through bills of lading and physical connection between rail and water agencies. It is a waste of capital to construct separate systems of warehouses and terminals for railroads and waterways when they can be used jointly by both methods of transportation. Legislation, in order to be effective, must require terminal and wharfage charges to be reasonable whether these facilities are owned by railways or waterways.

There are many advocates of legislation which would give the Interstate Commerce Commission the power to prescribe minimum rates for railroads. Such legislation would rest upon the theory that the lowering of rates as a general proposition oftentimes operates merely for the benefit of a favored few who are able to take advantage of them, and that, applied to railroads, the exercise of such a power would prevent that ruinous competition between rail and water routes which drives the boats off the rivers and canals of the country. In France there is a fixed rule that there shall be a difference in rates of 20% in favor of the waterways, and in case railways in competition with waterways desire to fix lower charges for the carrying of freight, application must be made to a commission which invariably refuses permission if water transportation would in any way be prejudiced or placed at a disadvantage.

The commission can not see its way clear to recommend a general power to fix minimum rates. In the development of the country a lowering of the cost of transportation is an important factor in promoting industries and commerce. The general tendency has been toward lower rates, and any regulation which would directly or indirectly interfere with this tendency would probably be injurious rather than otherwise. A majority of the commission, however, would recommend giving the power to the Interstate Commerce Commission to prescribe minimum railroad rates whenever, in its opinion, the object of a railroad in reducing rates is to destroy waterway competition.

In dwelling upon the disadvantages of waterways we do not omit to mention the handicap which has existed on numerous rivers because of the delay of the Government in prosecuting projected improvements. This delay operates as a disadvantage, because those who contemplate the building of boats and the establishment of steamboat or barge lines are unable to proceed with confidence. On the other hand it should be said that the danger of ruinous railway competition is a far more serious obstacle to the development of waterway traffic. Under this competition many channels which afford ample depth and the opportunity for the economical shipment of freight have remained largely in disuse. The criticisms upon the policy of Congress because the development of water routes has not been prosecuted with greater rapidity fail to take into account the substantial facts which have in the past discouraged the development of river transportation.

Mention must also be made of the fact that in numerous instances, although appropriations for the improvement of channels have been sufficiently large to create a high degree of efficiency for purposes of navigation, the use of the improved channels has not been at all commensurate with the expense incurred, one reason being a noticeable lack of progressiveness in providing suitable boats or other means of conveying freight, and another, the failure to provide terminals having modern equipment and facilities.

No improvement by the Federal Government will suffice without the cooperation of communities and business interests upon which reliance must be had for the proper utilization of improved waterways.

It is advised that by legislation, and in every way possible, cooperation be also secured between rail and water routes. Especially where such cooperation can be secured, or suitable railroad service does not exist, the commission would recommend the improvement of waterways, which, on expert examination, are found to be profitable investments of capital and will be of economic value as a means for transportation. Such improvement, it is believed, will greatly promote general commerce and the development of the industries of the country.

In the course of their investigations the members of the commission have observed the lack of comprehensive statistical information upon inland waterway traffic. In some localities, as at the locks at Sault Ste. Marie, detailed statements are carefully prepared under the direction of the Army Corps of Engineers, giving the quantity and quality of the freight and the number of passengers carried through the locks. Other reports made by the Corps of Engineers afford valuable information, though, in some instances, incomplete.

Available statistics are furnished by several different bureaus of the Government, but are strikingly lacking in uniformity and in sufficient classification as well. The terms "general merchandise," "miscellaneous merchandise," "unclassified freight," "package and packet freight" are used in the same general sense, though quite ambiguously as to what categories of freight are included.

It is recommended as desirable that a uniform system be established applicable to all waterways, under which statistics may be collected showing the volume and different kinds of traffic carried on the rivers and inland channels of the country. This will not only be valuable in affording suggestions as to the extent to which waterway traffic is increasing or diminishing, and thus assist in determining the legislative policy to be pursued, but will also afford information of very considerable service to the commercial interests of the country. It is to be noted that we are far behind several countries of Europe in the accuracy of statistics relating to inland navigation. It is desirable that the statistics should show not merely the number of tons carried and the money value of the same, but the distances over which commodities are transported, so that not only the number of tons carried may be ascertained, but the ton mileage as well. In many respects statistics of the latter are more valuable than of the former. In some instances ferry traffic which is carried a half mile or less is placed upon the same footing with traffic carried a thousand miles or more.

It is a question of detail for Congress to consider what agency shall be intrusted with the collection of these statistics. It is thought that the necessary information can be obtained by the expenditure of a comparatively trivial sum of money, and the duty may be imposed upon existing bureaus and officials, such as the army engineer corps, the collectors of customs where the navigable channels are near to custom houses and those engaged in the Steamboat-Inspection Service. Rules requiring masters or owners of boats to report the quantity of freight and the distance it is carried should be enforced.

The commission would also call attention to the desirability of more extensive information regarding the high-water, low-water, and average-water discharge of the various rivers of the country. Information of this kind has been collected for some time on the Mississippi River from its source to its mouth. Fairly accurate statistics are already available for the high and low water depths of this and other streams, but in addition to this it is recommended that statistics be collected and made available for the high and low water discharge. This will require a more extended examination of cross sections and velocities at typical places. Accurate information upon these points is necessary in order to frame and execute properly devised plans for river improvement. The cooperation of commercial bodies in furnishing statistics should be encouraged.

II.—Canals: Including the Advisability and Practical Value of Canals for Deep-Draft Vessels.

Many advocates of the building of canals manifestly fail to take into account the very great advantage of natural waterways over artificial channels for purposes of navigation. Natural waterways have banks which have been formed through an unlimited time and are adapted to the flow of water between them. Save in arable soil the banks have a certain degree of stability and opera as a bulwark against the wash or swell created by t passage of boats. Natural waterways pass through valley and usually close to large and populous communiti which have been located and developed in former da largely because of river transportation facilities. Th are available for the passage of boats, and possess extr width at many places, by reason of which the develo ment of docks and basins is much facilitated witho extra cost for right of way. For a large portion of ea year, during the high-water season, they allow th passage of boats of unusual draft.

Artificial channels may be constructed along straighter line. but usually with great difficulties in th acquisition of property for their construction, as well a in the overcoming of differences in elevation; and topographical conditions may cause the route not only to pas at a distance from the existing large and populous communities, but also to traverse regions where developmen may naturally be slow. Again, canals must be provided with protected banks to resist the great force of wate which is put in motion by the passage of boats or barge through their channels. They are naturally limited in width because of the expense; the cost of a width sufficient for the handling of ocean boats is practically prohibitive, except for comparatively short distances. They may have an advantage in their greater freedom from silt or other obstructions to navigation, but this is ordinarily more than counterbalanced by the difficulty of obtaining an adequate water supply for the main channel or for the locks used in connection with it.

The commission has had under consideration the question of the construction of artificial canals adapted to the passage of seagoing ships. An examination of this subject has led to the conclusion that this class of waterways is only profitable under certain well-defined condition, of which the following are the best illustrations:

First. Canals connecting navigable waters located near to each other, between which large traffic would naturally exist, except for rapids, a barrier readily overcome, or the existence of a comparatively narrow strip of land. The Sault Ste. Marie Canal connecting Lakes Superior and Huron, is perhaps the best example. This canal, 1.6 miles in length and constructed at a cost of about $9,300,000, renders the almost unlimited resources tributary to Lake Superior available to the other lakes and provides for a return commerce considerably less in volume. Other illustrations are the Welland Canal, 26¾ miles in length, with 26 locks, connecting Lakes Erie and Ontario, and the Lachine Canal, constructed for the purpose of obviating rapids in the St. Lawrence River.

Second. Comparatively short canals, which save a very great sailing distance, such as the Suez Canal, 87 miles in length, which furnishes a substitute for the voyage around Cape of Good Hope and saves in the sailing distance from Northern and Western Europe to Calcutta 3,700 miles, and to Hongkong, by the Straits of Sunda, 3,300 miles. Also the proposed Panama Canal, 49 miles in length, which obviates a voyage around Cape Horn and saves in the sailing distance from New York to San Francisco more than 8,000 miles. Another illustration is the Kaiser-Wilhelm Canal, 53 miles in length, which, though constructed primarily for military purposes, is largely used for commerce and saves in distance for vessels bound from the English Channel to the Baltic about 200 miles.

Third. Canals from the sea to large cities situated not far from the coast, where communities have grown to large size and become great producers or consumers of freight, without connection with the ocean. In these cases, with increased commercial and manufacturing importance, it has become a practical necessity to establish communication with the sea. The best illustration of this class is the Manchester Canal, 35½ miles in length. with a least depth of 28 ft. The canals in Belgium, from the North Sea to Bruges, to Ghent, and to Brussels, are also good examples of this class.

The reasons for the disadvantages of canals as compared with natural waterways are obvious. In a narrow channel a boat moves with much less speed and with far greater difficulty and danger than in a natural waterway where there is sufficient sea room. Since the speed of the slowest boat determines the speed of all, it is not probable that any time could be gained by using a canal unless the distance saved were very considerable. Also, there is the constant danger that in the handling of a large vessel, which is not adapted for navigation in a narrow channel, it will strike against the bank or works of construction and not only incur delay but also serious damage. This possibility increases the cost of insurance. It is conceivable, however, that with improved methods of handling vessels this disadvantage might be somewhat lessened.

It should be added in this connection that persons familiar with navigation have stated, in answer to inquiries on this subject, that even if canals of deep draft should be constructed on certain proposed routes in this country and were entirely free from tolls or similar charges, large vessels would make no use of them, preferring to go where there is greater sea room. Ocean-

going boats are so expensive in first cost and daily operation that the profits of a whole trip may be consumed by a few days' extra delay. Moreover, the expense per ton of carrying capacity is much greater for an ocean-going boat than for one used in interior waters. The model, also, and the method of handling is different. This difference in cost tends to neutralize any advantage gained in the use of artificial channels by ocean-going boats.

The higher average value per ton of carrying capacity for seagoing vessels over those of inland waters is shown by the following table, compiled from the United States Census Report on Transportation, page 21, which gives the figures for 1906:

	Average value of vessel per ton of carrying capacity.			
	Steam.	Sail.	Unrigged.	All vessels.
Atlantic coast and Gulf of Mexico.	$133	$33	$18	$56
Pacific coast (including Alaska)....	117	38	30	78
Great Lakes & St. Lawrence River.	61	27	32	55
Mississippi River and tributaries..	90	..	2	5
All other inland waters.....	103	32	10	18
Entire United States.....	95	33	9	39

It thus appears that the average value of vessels per ton of cargo-carrying capacity on the Atlantic coast and Gulf of Mexico is $56, on the Pacific coast $78, while on the Mississippi River and its tributaries it is only $5.

III.—The Necessary Steps to be Taken Before the Adoption of Projects for the Improvement of Rivers and Harbors and the Method of Making Appropriations Therefore.

The commission regards the present law, providing for preliminary steps before the adoption of projects for improvement, as well adapted to secure the best results. Under existing statutes it is required that when the improvement of a river or harbor is advocated, before any plan is adopted there should be legislation by Congress in the form of a concurrent resolution or other measure which shall direct that an investigation of the improvement be made. This investigation contemplates two successive steps—first, a preliminary examination; second, a detailed survey—both of which are made by the Engineer Corps of the United States Army, and are reviewed by an organization known as a "Board of Review," created by the River and Harbor Act of 1902, with the object of securing uniformity in recommendations before projects are adopted, and with the thought of bringing to bear upon the proposed improvements under investigation a more elaborate and careful consideration. If on the first or preliminary examination the report is unfavorable, no further action is taken without the further order of Congress. The law on this subject is contained in the River and Harbor Act of March 3, 1909. It is as follows:

> In all cases a preliminary examination of the river, harbor, or other proposed improvement mentioned shall first be made, and a report as to the advisability of its improvement shall be submitted, unless a survey or estimate is herein expressly directed. If upon such preliminary examination the proposed improvement is not deemed advisable, no further action shall be taken thereon without the further direction of Congress; but in case the report shall be favorable to such proposed improvement, or that a survey and estimate should be made to determine the advisability of improvement, the Secretary of War is hereby authorized, in his discretion, to cause surveys to be made, and the cost and advisability to be reported to Congress. Such examinations and surveys shall be reviewed by the Board of Engineers for Rivers and Harbors, as provided in section three of the River and Harbor Act of March second, nineteen hundred and seven: Provided, That every report submitted to Congress in pursuance of this section, in addition to full information regarding the present and prospective commercial importance of the project covered by the report, and the benefit to commerce likely to result from any proposed plan of improvement, shall contain also such data as it may be practicable to secure regarding (first) the establishment of terminal and transfer facilities, (second) the development and utilization of water power for industrial and commercial purposes, and (third) such other subjects as may be properly connected with such project: Provided further, That in the investigation and study of these questions consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures made in the interest of navigation: And provided further, That the investigation and study of these questions as provided herein may, upon review by the Board of Engineers for Rivers and Harbors when called for as now provided by law, be extended to any work of improvement now under way and to any locality the examination and survey of which has heretofore been, or may hereafter be, authorized by Congress.

Under the foregoing plan if the final report is favorable, it is considered that a basis exists for the making of an appropriation for the proposed improvements. The recommendations of the engineer officers are not necessarily final, though since the passage of the law the rule has been adhered to as a fixed policy that no project should be undertaken by the Government or appropriated for which does not have the recommendations of the board of review and the Chief of Engineers. At the time of the creation of the board, in 1902, projects of an aggregate cost of $400,000,000 or more, recommended as worthy of improvement, either had not been commenced or were in a partly finished condition, and necessarily the work of Congress was one of selection, under which the most pressing projects alone were sure of attention.

The commission would advise that without a careful and unbiased examination of proposed improvements of the nature now required by statute, no project should be adopted by Congress. Numerous propositions have been made for the creation of a board of public works, or other body, which shall decide upon the feasibility and desirability of propositions for expenditures on rivers and harbors. The commission is unwilling to recommend a change of this kind, and points to the fact that the past recommendations of the Engineer Corps have been carefully prepared and with a degree of expert knowledge and comprehension of the commercial needs of the country which could not well be supplied by any other body or organization.

The advantages which attach to the Engineer Corps are obvious. The members are in the permanent service of the Government, and are free from those influences which would inevitably be brought to bear upon men in civil life. Those engineers now engaged in the work are carefully trained in the planning and execution of these improvements, and have special qualifications for judging the feasibility and the cost of proposed river and harbor projects. They also have a good general knowledge of the probable commercial results which would accrue, though on this point their opinions have not been regarded as conclusive. In this connection the commission would call attention to the necessity for an increase in the membership of the Engineer Corps.

The commission would recommend that hereafter the general policy be adopted of providing for the early completion of any and all projects which are undertaken, and that only such number of projects should be commenced as will be appropriated for and completed within a reasonable time. In this way definite results can be relied upon, plans can be made for the utilization of the streams improved, and, in addition, a very large saving in expense may be secured. If this is done, projects will be more carefully considered before they are adopted. Careful provision should also be made for the maintenance of existing works, otherwise the improvements already made will deteriorate. In the general policy of improving streams in waterway systems, it is advised that the main stream be improved first and raised to an adequate stage of efficiency at an earlier date than the tributary streams; that in the improvement of any particular river, preference should be given to the lower portion, and that the improvement should proceed from the mouth up, unless the regimen of the river makes a different rule desirable, or an independent stretch of the river exists remote from the mouth upon which salutary results can be more readily obtained.

There are manifest benefits in securing standardization or equal depths in all channels, so that boats of the same size may be utilized everywhere. This would prevent the very considerable expense of loading and unloading whenever there is a transfer between channels of different draft or capacity. If a uniform depth can be secured, especially in locks and improvements of artificial construction, it should be accomplished. The fact, however, must not be overlooked that the very great difference in the size of the streams which make up any river system renders complete standardization difficult and exceedingly expensive, if not impossible.

The continuing contract system was first tried in the year 1890. Under this plan the whole or any part of an estimated expenditure is, whenever desirable, authorized at one time, and the amounts needed as the work progresses are provided from year to year by appropriations carried in the sundry civil act. This system, to some extent and with beneficial results, has been used in each subsequent river and harbor act, except in 1894, and its continued use is recommended. In the case of small streams or harbors, however, it is not essential. Nor is the authorization of a contract for completion desirable, as a rule, in the case of very large projects, where the amount necessary for completion is indefinite or a very long time is required. In many instances the work extends over a long period, because the necessary plant or equipment must be collected gradually, and the work, if hastened too rapidly, becomes unnecessarily expensive. In these cases, as well as in others, a large discretion as to time of completion is necessarily left to the executive department, which can carefully consider all phases of the situation and secure such prosecution of the work as will be most beneficial to all concerned.

IV.—The Proper Division Between Appropriations by the Federal Government, on the One Hand, and by the States, Minor Political Divisions, and Individuals, on the Other Hand.

Numerous propositions have been made for a change of policy by Congress, so that the expense of river and harbor improvements shall be divided between the Federal Government and states, cities or communities, and individuals. Widely different policies have been adopted by various countries in the making of river and harbor improvements. It is difficult to draw any exact line in the classification of these policies, but, roughly speaking, it may be said that there are three methods employed.

1. That under which these improvements are left to individual or local enterprise, with the right to impose tolls upon the boats which utilize them. This policy is best illustrated in Great Britain, where the improvement of inland waterways, such as canals and rivers, is, with few exceptions, prosecuted by private corporations or navigation companies. Harbors in Great Britain are improved either by municipalities, as at Bristol and at Southampton, in the first instance, or by railway companies which desire seacoast terminals, or by dock and harbor boards affiliated with the city government, as at Liverpool. In all these cases the construction of docks, the dredging of channels, and the building of breakwaters are taken care of by the same company or agency. In practically all cases tolls are charged.

2. That under which the General Government prosecutes improvements and levies tolls. This is well illustrated by certain harbor improvements in France, where, in addition to the dredging of the channels, the Government provides docks and harbor facilities.

3. That in vogue in the United States, under which the General Government improves rivers either by open-channel work or by the construction of locks and dams, and charges no toll therefor, rendering navigation entirely free. Under this method in the United States there is likewise an improvement of harbors by the dredging of channels or anchorage spaces. Provision is also made for protection against the sea by breakwaters or otherwise. These improvements are not made the basis of a charge, though port dues are imposed, as in most, if not all, countries without regard to improvements made. This method, so far as it relates to canals and canalized rivers, was also adopted in France in the year 1879, and is still in vogue in that country, except as regards a considerable number of new works provided for in 1903 or later, under which there is participation in the expense, the General Government, as a rule, bearing 50% of the cost, and localities immediately interested the balance. In this case the localities which contribute money for the improvement are authorized to collect tolls for their reimbursement.

In our own country, until the time of the Civil War, no considerable amount was expended for the improvement of rivers and harbors. For the most part our rivers were neglected, and in many cases, as in Ohio, Illinois and New York, canals were constructed at the expense of the state, though oftentimes with the aid of a grant of land from the Federal Government. Many canals were constructed by private companies. This class of improvements was regarded by one school of public men as outside the scope of the Federal Government, and for decades was vigorously opposed in many parts of the country. The constitution of the Confederate States of America, framed at Montgomery in February, 1861, in the enumeration of the powers of the General Government, contained the following provision, which may be said to express one interpretation of the Federal Constitution on this point, as well as one view of the best policy to be adopted:

> To regulate commerce with foreign nations, and among the several states, and with the Indian tribes; but neither this, nor any other clause contained in the constitution, shall ever be construed to delegate the power to Congress to appropriate money for any internal improvement intended to facilitate commerce except for the purpose of furnishing lights, beacons, and buoys and other aids to navigation upon the coasts, and the improvement of harbors and the removing of obstructions in river navigation, in all which cases such duties shall be laid on navigation facilitated thereby, as may be necessary to pay the costs and expenses thereof.

In recent years there has been a noticeable lack of uniformity in the method of providing funds for these improvements. The state of New York in the year 1903, by popular vote, adopted a constitutional amendment providing $101,000,000 for a barge canal. In the year 1908 the people of Illinois, by the same method, voted an amendment to the constitution which allows the issue of bonds by the State to an amount of $20,000,000 for part of the expense of a deep waterway from the Lakes to the Gulf. In the original authority for the Chicago drainage canal, provision was made that it might be a link in, or part of, a navigable waterway from the Lakes to the Mississippi River. At a very recent date provision has been made for a private canal in the state of Massachusetts, with a view to shortening the sailing distance and avoiding the dangerous passage in the open sea around Cape Cod. This enterprise contemplates the expenditure of private capital for the construction of the canal, also the charging of tolls.

In numerous instances in other states, as in Oregon, Washington, Ohio, Pennsylvania, and California, provision has been made for waterway improvements, either independently or in cooperation with the General Government. Some municipalities have also voted large sums for harbor improvements. At the last session the Legislature of Texas passed a law (see General Laws of Texas, 31st Legislature, pp. 32 to 45) authorizing the formation of navigation districts, which districts may issue bonds, levy taxes, and condemn property in the prosecution of

river and harbor works. At the last general election, in 1909, the people of Rhode Island authorized the expenditure of $500,000 for the improvement of Providence Harbor.

The commission finds that, in the development of waterways on a large scale, the decided tendency in other countries is toward a degree of participation by communities and localities especially benefited and is of the opinion that in order to obtain the best results this policy must ultimately be adopted in our own country. In the meantime, it is desirable to encourage participation by communities whenever their proposed improvements are worthy of recognition by the Federal Government. The objections to this plan of participation are that the necessity of including different localities and states in a single improvement would require a concert of action by numerous and perhaps varying interests, often impossible to obtain. This applies especially in the case of rivers passing through or by several states. Another objection is that less-deserving projects, presented with offers to furnish a portion of the cost, might obtain recognition to the exclusion of more useful projects for which less pecuniary support could be furnished.

On the other hand, it can not be denied that in most instances river and harbor improvements confer an especial benefit upon portions of the country most nearly affected; that there is a constant danger of insistent pressure upon the Federal Government for the expenditure of money upon projects which have not been maturely considered, and which, if part of the burden were chargeable to the localities in which they are advocated, might not be presented to Congress. Again, in the accomplishment of any large and comprehensive plan for the full development of inland navigation throughout the country, and of the associated uses of water, the cooperation of all communities and interests is especially desirable. There is the further fact that terminal facilities are an integral part of any well-devised plan for waterway improvement. These, at least, should be provided by the communities immediately benefited.

It has been brought to the attention of the commission that in some instances heavy burdens have been laid upon traffic by exorbitant charges for the privilege of mooring at wharves owned by municipalities or private individuals. There is a palpable unfairness in these cases, because the Federal Government is expected, without burden on the communities interested, to expend its money for river and harbor improvements, while the communities themselves show no disposition to cooperate, and, in a measure, nullify the benefits secured by the large Federal expenditures.

In passing from this subject the commission would recommend:

1. That in the improvement of rivers and harbors similarly situated, where equitable division is possible, uniform rules be observed for a proper division of cost between the Federal Government and minor political divisions. There is at present a lack of uniformity. One illustration of this is in the improvement of interior channels and harbors. In some cases the expense is borne exclusively by the Federal Government and in other cases by the municipalities interested.

2. That participation in improvements by local communities be encouraged, always with due care to avoiding the adoption of projects which are unworthy of recognition by the Federal Government.

3. That improvements not essential to navigation should not be undertaken by the Federal Government.

4. That improvements in rivers and harbors be not made unless sufficient assurance is given that proper wharves, terminals, and other necessary adjuncts to navigation shall be furnished by municipal or private enterprise, and that the charges for their use shall be reasonable.

V.—The Relation of Waterway Improvements to Bank Protection, Flood and Drought Prevention, Irrigation and Drainage.

In providing for the future development of the country, consideration must be given to the fact that water, as well as land, is an asset which makes up an integral part of our natural wealth. Waters must ultimately be utilized not merely for navigation, but also for irrigation and for power, when available for these purposes; also, all practicable means must be used for their clarification and for the prevention of floods and droughts.

It is desirable that whenever navigation is improved the most careful attention be given to these other associated objects, and while it is not the opinion of the commission that waterway improvements for the development of navigation should be deferred until a comprehensive and final plan for the utilization of waters can be devised, on the other hand subjects pertaining to the control and most beneficial utilization of water should at all times be considered, and improvements looking to the promotion of navigation should, as far as possible, harmonize with the general uses and beneficial control of waters. The subject of water power receives separate attention under heading VII. of this report. Irrigation projects are now provided for by separate legislation under an act of Congress passed in 1902. All reasonable means for the prevention of floods should be utilized. Water when uncontrolled becomes a most destructive agency. One of the most injurious of its effects is in the erosion of banks, which varies greatly with the periodical changes in river level and which is usually greatest during high floods or during their subsidence.

It should always be borne in mind that the waterway improvements made by the Federal Government under the exercise of its authority should be restricted to navigation. Whenever bank protection or flood prevention or the clarification of water is the sole object of improvements, the question presents little difficulty in its solution. Such projects are not a proper charge upon the Federal Treasury. A more difficult problem, however, is presented where the improvements just mentioned have as their object both navigation and the protection of private property. In such cases, in the opinion of the commission, the expense should be apportioned between the Federal Government and communities directly interested. In many instances proposed improvements have as their main object the protection or benefit of private property. In such cases there is a distinct benefit conferred upon individuals or localities which is only of a remote or very indirect benefit to the country as a whole. Lands subject to periodical overflow or lands of uncertain value because of the danger of erosion, when improved, are multiplied many times in value, and there is a constant danger that such improvements will be advocated under the guise of river and harbor legislation framed to benefit navigation, when the real object is the benefit which will accrue to individuals or localities.

Beginning in 1902, river and harbor acts have provided that the protection of banks should not be appropriated for out of the National Treasury unless the improvement is required in the interest of navigation. The levees upon the lower Mississippi are an apparent exception to this rule, but when the construction of these levees was first undertaken by the Federal Government they were regarded as necessary for navigation and as an essential feature in securing a proper regimen for the Mississippi River. The question whether they are an aid to navigation is one which has been much discussed, some stating that they promote navigation and others that they do not, the prevailing opinion being that they have a direct effect upon the maintenence of the channel and an indirect effect upon navigation. In any event, more than half of the cost of these levees constructed since the time when the Federal Government commenced to have part in their construction has been borne by the states or communities bordering upon the river. Drainage projects can be advantageously prosecuted in conjunction with navigation improvements. The prevention of overflow during floods is helpful to navigation, though not essential to its existence. The line should, however, be carefully drawn between improvements which, in whole or in part, are for the protection or development of private property and those which are made in the sole interest of navigation.

Measures must ultimately be taken to permit and facilitate the greatest possible protection of property abutting on navigable and non-navigable streams. It is desirable for the proper conservation and utilization of the resources of the country that these valuable lands should be protected. The commission would, however, repeat in this connection the recommendation made in No. IV., that improvements by the Federal Government be restricted to those essential to navigation, and would also recommend that, whenever a project is under consideration or is in operation under which a very considerable amount of land will be reclaimed or protected from overflow, a survey be made and report be submitted as to the cost of the reclamation features of such project and as to the probable quantity and value of the land which would be reclaimed or benefited thereby.

VI.—Policy Relating to Harbors, Including the Ownership and Control of Wharves and Docks.

The question of the improvement of harbors, as a general proposition, presents little difficulty. The liberal policy heretofore pursued by the Government in this regard has greatly benefited the public and has resulted in a great increase in wealth to the country at large. The harbors so far improved have furnished outlets for our exports and made the products of immense areas in the interior readily available for shipment abroad or for use at home. They have been useful both to the foreign and coastwise trade, and made possible the entrance of boats of the deepest draft, thus greatly diminishing the rates of freight on ocean shipments. In addition, the construction of breakwaters and other means for the protection of the available space within numerous ports of the United States has served a most beneficent purpose in the more adequate protection of human life. These ports have as feeders not only the river systems and canals of the country, but also its great network of railways. It must be conceded that in comparing the benefits conferred by harbor improvements with those of river improvements, the former have been more uniformly helpful, though in some instances the appropriations for river and lake channels have brought an equal or even greater return than usually results from expenditures upon harbors.

The commission recommends the continuance of a progressive policy which has been adopted relating to harbors, but would advise a division of harbors into classes by depth or by the importance of their ocean or coastwise traffic. The greatest channel depth, which now is 30 to 40 ft., is not required save in great entrepôts of commerce, in the development of which it is probable that even greater depths than those now required may in time become necessary. Uniform and reliable channels, which can be depended upon for a certain depth and width from year to year and at all times, are the first essential.

The commission recommends care in avoiding an undue multiplication of ports; that is, it is undesirable to have three or four minor harbors insufficiently developed in a locality where one well-improved port will serve the purpose. Under the stress of local demands harbors have in some instances been improved where the money could have been more economically expended in the better development of those already in existence.

In recommending the improvement of harbors on a liberal scale the commission calls attention to the necessity for rendering them useful to the largest possible number, and thereby preventing a monopoly of benefits by a few corporations or individuals. Instances are not lacking in which the land suitable for terminals adjacent to improved harbors is owned by one corporation or by a comparatively small number of individuals. If improvements should be considered desirable where the number of water-front owners is small it is advised that a condition be carefully imposed to the effect that wharfage facilities shall be made available to the public generally, and that the charges for the same shall be submitted to the Secretary of War or other official for his approval.

It is also recommended that a proper dividing line be drawn between the work to be done under appropriations by the Federal Government and that by cities and individual owners. Provision for a safe entrance into a bay or harbor sufficient to afford safety to shipping and suitable anchorage grounds in proximity to cities thereon is the full duty of the Federal Government. Minor channels leading to wharves in harbors as well as upon rivers should be provided by communities or individuals.

The construction of wharves and docks by the Government has been advocated; but the commission is unwilling to recommend such a policy. In the first place, the total expense of harbor improvements would be greatly increased, and under such a policy money which might be expended for general purposes would be used for work that should more properly be left to municipalities or private parties. In deciding whether a harbor improvement is to be adopted or not, it is wise to omit those cases where there is not assurance that local or private enterprise will furnish all needed terminal facilities.

VII.—Relation of Waterway Improvements to Water Power.

The commission has had under consideration the use of water power in connection with the development of navigation, as well as plans for the utilization of power and the right of the Federal Government to control or use the same.

The subject of water power is not within the scope of the inquiries of the commission, except as it is associated with navigation. The members, however, have given much attention to this general subject and strongly recommend the greatest care in the conservation of water power for the use of the people. Its value has not been fully understood, and power derived from navigable and non-navigable streams will undoubtedly be developed to a much greater extent in the future and for a larger variety of uses. The commission especially recommends such legislation by Congress and by the states as would prevent monopoly in the possession of water power, and secure, to the greatest possible degree, its utilization for the general benefit.

The rights of the Federal Government in water power may be viewed from three different standpoints:

First. Cases in which power is developed on streams located in public lands, where undoubtedly the Government, so far as the rights pertaining to abutting ownership are involved, has full control, and should exercise the greatest care in granting away whatever rights it may have.

Second. When power is developed in non-navigable streams, where there is private or state ownership, in which case no Federal authority to regulate or control exists, except to prevent interference with the navigation of other streams.

Third. When water power is developed in navigable streams. In this case several plans have been proposed for the collection of tolls upon the water power developed by dams whenever their construction is permitted by Congress. The right of the Federal Government to collect such tolls must rest on one of three theories:

1. That the Federal Government has some proprietary right in the waters of navigable streams, so that the collection of tolls can be based upon actual ownership of, or right in, the waters.

2. That, as the right to grant or withhold consent for the construction of a dam in navigable waters rests in Congress, it is allowable to make a charge for the consent or privilege and authorize the collection of tolls.

3. That the Federal Government in its jurisdiction of interstate commerce has control of navigable streams and has a certain degree of responsibility for their improvement. Under this theory it is maintained that tolls upon the water power developed can be collected and paid into a fund for the improvement of navigable streams, including not only the one on which the toll is charged, but all others capable of improvement for navigation.

The commission is of the opinion that the Federal Government has no proprietary right or interest in navigable waters which would authorize the collection of tolls. The right, if it exists at all, rests upon either the second or third theory stated. As regards the second theory, it should be said that the imposition of tolls, unless based upon a more substantial foundation than the mere authority to grant or withhold consent—an authority arising solely from the control of the Federal Government for the purposes of navigation—does not commend itself to the commission, and it is to be doubted whether, even in case a bill should be passed or other action taken by Congress for granting this permission, with a provision for charging tolls, such tolls could be collected.

Regarding the third theory stated, it should be noted that under the exercise of the taxing power Congress can levy taxes for general revenue purposes upon all classes of water power, whether in navigable or non-navigable streams, and if charges are to be imposed it would seem that this is the normal method. It should further be borne in mind that a requirement for the imposition of tolls where the right to construct dams is hereafter granted would cause a discrimination between water power to be utilized under future permits and those already enjoyed, which are subject to no such charge. It must of course be remembered that whenever the privilege of constructing dams is granted in a navigable stream there is an undoubted right to impose charges sufficient to pay the expenses of examination and supervision and to secure the Government against cost by reason of obstacles to navigation created by the erection of dams; but this rests upon an entirely different principle from the proposal to charge tolls.

The control of the Federal Government over navigable streams has to do with navigation only, and in the exercise of this jurisdiction the plan commends itself to the commission of inserting in each grant or franchise under which the consent to construct a dam is given a condition that the grantee who constructs the dam must also, whenever necessary to subserve the interests of navigation, construct a lock suited to the locality and to the probable development of traffic, and also furnish power for the proper operation of the lock or locks. These requirements, rather than the imposition of tolls, appeal to the commission because they are free from legal objections and are in entire accordance with the objects for which the Federal Government has jurisdiction over navigable streams.

Whenever the Government constructs dams for purposes of navigation or irrigation, and, as an incident thereto, water power is developed, such power should be utilized and an adequate charge made therefor.

The commission would call attention also to another important step in the control of water power, namely, that before the right to construct dams in any navigable stream is granted there should be a careful survey of the whole stream, or at least of that portion the regimen of which will be affected by the proposed construction. In the development of water power there is danger that dams will be located or constructed in such a manner as not to accord with the most helpful development of navigation.

The commission accordingly recommends that whenever permission to construct a dam in a navigable stream is requested consent shall not be granted until a survey has first been made and the proper location of dams has been determined.

It may also be stated that it is the opinion of the commission that if constitutional authority therefor exists, a provision should be inserted in these grants giving to the Secretary of War or other official the right to regulate charges for power furnished to consumers.

A provision reserving to Congress the right to alter, amend, or repeal should be inserted in every act granting water-power rights.

VIII.—Methods in the Improvement of Rivers, Including the Construction of Locks and Dams.

The general course of river improvement for purposes of navigation in both Europe and America is, briefly, as follows:

1. A river survey.
2. The removal of trees, snags, and other accidental obstructions.
3. The straightening, deepening, buoying, and lighting of the natural channels.
4. The revetment of banks to stop their erosion and the construction of levees to prevent outflow over the banks.
5. The regularization of the open river, or the standardizing of its bends, its cross sections, and its water slopes, obtained by longitudinal dikes which direct the water flow and form new banks, by spur dikes which determine the channel and regulate the waterflow, and by occasional submerged cross dikes which protect the bed of the river from excessive erosion, and maintain general river slopes.
6. The canalization of the river, obtained by the use of dams converting the river into a series of deep-water pools, and by the use of locks or other means of raising or lowering boats from each pool to the adjacent one.

The last two steps are often alternative propositions.

Such a plan of improvement is being followed on nearly all the navigable rivers of England, France, Belgium and Germany, about half of which have already been carried through the entire program.

In all the above stages of improvement the United States has little to learn from Europe in methods.

The Mississippi River from St. Paul to the mouth of the Missouri is a good example of a river which, from its moderate slope, good low-water discharge, and moderate high-water discharge, is capable of an excellent natural open-river navigation for light-draft boats; which can easily be regularized for medium-draft boats; or which can be canalized for boats of any draft. From the mouth of the Missouri River to the Gulf, the Mississippi, with its large low-water and large high-water discharge and mobile bottom, can be regularized, though engineering difficulties render the cost per mile greater than any other river work in the Mississippi Valley system. But it can not easily be canalized. The Ohio River, on the other hand, on account of its small low-water discharge can not easily be regularized for even light-draft boats, although it can be canalized for medium drafts.

Regularization of a river to give a good open-river navigation is only practicable on rivers with a gentle slope of river bed and a large low-water flow compared with a freshet flow, such as the Mississippi River below St. Paul, the Missouri River below the Yellowstone, the lower portion of many of their tributaries, the Hudson, the lower portion of the Atlantic and Gulf rivers in America, and in Europe the Rhone, Garonne, Durance, Loire, Lower Meuse, Rhine, Weser, Elbe, Lower Oder, Vistula, Memel, Danube, Dnieper, Volga, and the tidal portions of other rivers. But even in these cases, on the lower and most favored parts of the Rhine above the Dutch frontier, and the middle parts of the Danube, the low-water flow has neither justified nor secured a low-water channel depth of over 3 metres (9.8 ft.), nor of over 2 meters (6.6 ft.) on the other European rivers, and one some of these rivers only as much as 1 meter (3.3 ft.). A greater depth will probably require canalization. However, these depths, combined with the free, open river circulation, a perfected boat service, and fine terminal facilities, have on the German rivers led to an enormous tonnage of water traffic. North American rivers, as a general rule, surpass European rivers in length, in depth, and in water flow. The Rhine and the Danube are the only rivers of Europe, outside of Russia, with a greater low-water flow than the upper Mississippi River above the mouth of the Missouri.

Whenever the river slope is too steep and the corresponding current too great to be easily ascended by ordinary tows, and an open-river navigation is still preferable to canalization, the boat service is sometimes maintained by the aid of special chains or cables, laid under water along the bottom of the river, by which the boats pull themselves upstream. The use in Europe, however, of cables or chains is diminishing rather than increasing. In the United States there are but few places where this system would be useful.

Where the river slope is steep or the low-water discharge is small or where a draft greater than practicable by open-river methods is desired, the river improvement is usually best obtained by canalization.

The movable type of dam is the one most common in river canalization work, its great advantage being that it lies flat on the river bottom during high waters and opens the entire river to free navigation as long as the high water continues.

The earliest and most persistent type of lock and that still most generally used everywhere is the ordinary masonry lock, composed of two masonry side walls, closed at each end by movable doors or gates, the resulting inclosure or chamber being furnished with valves and passages by which it can be filled with water from the upper pool and can discharge its water into the lower pool.

When the boat traffic is very great and the highest pool of a river receives but little water from its tributaries, the lack of proper water supply may limit the river traffic and require either a change of lock construction to some other type using less water or else a pumping plant. A desire to economize water, combined with a desire to hasten the passage of boats through locks, is the main reason for the substitution during recent years of inclined railways or "canal inclines" and vertical lifts for the masonry lock. But the tendency of to-day in Europe seems to be toward retaining the masonry lock type, unless the conditions of dam location and of boat traffic are exceptional. In this connection, attention is invited to the fact that a high masonry lock is being built alongside of the Henrichenburg pneumatic lift on the Dortmund-Ems Canal, in Germany, and the hydraulic apparatus of the Anderton lift on the Weaver River canals near Liverpool, England, has recently been replaced by mechanical counterpoises and electro-dynamic machinery. There seems to be no good reason, therefore, for changing the existing practice in the United States, which is slow to give up the use of masonry locks.

Where a considerable height is to be overcome by masonry locks, there is usually a choice between the use of several locks of small lift and a lesser number with larger lifts. The present tendency is toward larger lifts.

In the matter of construction details, the European locks seen by the commission, while interesting as parts of the river improvement system, contained but few features not already in use in the United States.

There are many reasons why open-river navigation is preferable to a lock and dam or canalized navigation; among others, the capacity for practically unlimited traffic, easier travel during freshets, and very much greater speed of boat travel, especially downstream. One great recommendation of open river navigation is its relative economy. Canalization is almost always very expensive, both in first cost and in subsequent operation, so that its adoption must assume a reasonable certainty of great water traffic over the improved route.

While the growth of traffic may eventually demand with propriety either the thorough regularization or canalization of all navigable waterways, there are always in every country, and especially in the United States, many streams whose water slopes, water flow, character of banks and bed, etc., will render thorough improvement by either method above described too expensive to be justifiable from an economic standpoint.

IX.—Comparison of European Waterways with Those of the United States, Including an Investigation of European and American Transportation Rates Both by Land and by Water.

A majority of the commission made an inspection of European waterways in the months of August, September and October, 1909, visiting especially England, France, Germany, Holland, Belgium, Austria and Hungary. Typical harbors, as well as most of the important rivers and canals of these countries, were examined, and numerous conferences were held with the engineers and other officials having them in charge. In practically all these countries waterways have attained a high standard of development. This is due both to the fostering care of the states or political subdivisions and to private enterprise. In Germany, especially, and in fact in all countries except England, the increase of inland water-borne traffic has been marked, as shown by the following table, compiled from Volumes VI. and VII. of the Reports of the British Royal Commission on Canals and Waterways recently published.

TONNAGE OF EUROPEAN WATERWAYS.
[In 1,000 metric tons.*]

Country.	1875.	1880.	1888.	1905.	Percentage of increase.	Average annual increase.
England and Wales†	....	....	33,124	32,340	—2.4	—0.14
France	....	18,000	....	34,030	89.0	3.6
Germany‡	20,800	....	....	103,400	397.0	13.2
Belgium	....	24,836	....	55,345	114.0	4.5

*The total tonnage for these countries is calculated by adding together total receipts and shipments, but since this method is uniformly employed the percentages of increase are reliable.
†Excluding sea-borne traffic on the Manchester Ship Canal.
‡The tonnage of some minor streams is only estimated.

The great increase in water-borne traffic in Germany shown in the table above is mainly upon her important rivers. In 1875 the seven main rivers carried 60% of the total traffic and in 1905, 80%. On the Rhine alone between Kehl and the Dutch frontier 43% of the total traffic was carried, and on the Elbe between Hamburg and the Austrian frontier 24% was carried. The total length of free and canalized rivers and of canals in several European countries is shown by the following table, compiled from Volume VI. of the Report of the Royal Commission on Canals and Waterways:

CLASSIFICATION OF WATERWAYS.
[Length in miles.]

	Principal lines, Free rivers.	Principal lines, Canalized rivers.	Canals.	All waterways.
England and Wales	812.0	1,312.0	1,927.0	4,053
France	*796.0	970.1	1,776.7	7,485
Germany	1,948.0	425.2	894.8	6,200
Belgium	74.5	307.0	334.2	1,015

*The Loire for 106 miles between Briare and Nantes is paralleled by a canal and is only used by small boats.

According to Part I. of the Report of the Commissioner of Corporations on Transportation by Water in the United

States (see pp. 28, 29), there are 295 navigable streams in this country having a navigable length of approximately 26,410 miles. Forty streams, with a length of 2,600 miles, have a 10-ft. navigation, and 70 more, with an additional length of 3,200 miles, have a depth of from 6 to 10 ft., during the greater part of the year. The Mississippi River and its principal tributaries alone have about 2,500 miles of 6-ft. low-water navigation. There are at present in the United States 45 canals still in operation, with a length of 2,189 miles. Of these, 17 government canals aggregate 194.49 miles in length, 12 state canals aggregate 1,358.98 miles, and 16 private canals aggregate 635.58 miles. Hence the total length of all navigable rivers and canals in operation is about 28,600 miles.

Upon the Rhine, the most important inland waterway of Europe, the traffic has assumed enormous proportions, showing an increase greater than on any waterway of this country, except possibly the Great Lakes. In 1875 the average tonnage per mile upon this river for the 351 miles above the frontier of Holland was 1,560; by 1905 it had mounted to 11,400, an increase of 631%. On the canalized portion of the river Main, one of the smaller tributaries of the Rhine, the traffic has increased from 296,000 total tonnage in 1887 to 2,552,000 in 1905. This enormous increase has taken place in spite of the fact that the Rhine at no place above the Dutch frontier is more than 10 ft. deep at ordinary low water, and the depth of the Main is even less. The low-water depth of the Rhine is only 9.8 ft. for 110 miles from the Dutch frontier up to Cologne; thence 8.2 ft. for 82 miles to St. Goar; thence 6.6 ft. for 79 miles to Mannheim; and thence 4 ft. for 48 miles to Strassburg. The Main has a low-water depth of 7.5 ft. from the Rhine for a distance of 26.5 miles to Offenbach; and only 2.6 ft. for the next 217 miles to Bischberg.

The canals of all the European countries visited by the commission, except those of England, have shown in the aggregate a steady increase in traffic, although there are instances of abandonment or marked diminution. This increase has taken place on canals which, with few exceptions, are of shallow draft, the average depth being about 6 ft. In France the average annual increase has been about 3%. This is in marked contrast to the record of canals of this country, which, except for a comparatively few ship canals connecting the Great Lakes, show a decrease of 73% from 1880 to 1906. This decrease is partially explained by the fact that, since 1880, about 888 miles of canals have been abandoned.

The general policy of almost all European countries has been toward the development and improvement of their waterways, though of late years in a few instances projects already adopted have been abandoned or prosecuted without assurance of early completion. It is difficult to make reliable comparisons between the amounts expended for waterways in those European countries in which the General Government appropriates money for this purpose, and the amounts spent in the United States, partly because in Europe the expense of improvement is often shared by the state and the provinces, districts, and individuals affected, and partly because far greater amounts have been expended for wharves, ice harbors, local basins, and other facilities for harbors and river-borne commerce than is customary with us. Inland harbors especially are developed on a much more extensive scale in Germany, France, and Belgium than in the United States. The city of Frankfort, for example, is now carrying out new harbor works, the cost of which, including land purchase, will be approximately $17,640,000. The whole amount will be defrayed by the city without state aid.

From 1814 to 1900 the Government of France spent on inland waterways approximately $301,000,000 for improvement and construction (including levees, revetments, etc.) and over $148,000,000 for maintenance and heavier repairs. Belgium spent for the construction of state waterways from 1831 to 1905 about $77,000,000, and for current improvements and maintenance about $24,000,000. Between 1813 and 1906 Prussia spent for waterway construction and improvements about $129,000,000, and for maintenance in 1905 about $4,000,000. The congressional appropriations in the United States for the survey, improvement and maintenance of harbors and waterways from 1802 to March 2, 1907, amounted to almost $553,000,000, of which sum about $69,000,000 were spent up to 1906 upon canals and canalized rivers. In an official document published in 1903 the relative amounts appropriated for rivers, harbors, and canals to and including Dec. 31, 1902, is stated, namely, $221,869,759 for rivers, $147,448,903.32 for harbors, and $33,237,857.24 for canals. But it must be remembered that the United States is about eighteen times as large in area as either France or Germany, and the length of its navigable rivers and canals is nearly four times as great as in France and more than four times as great as that of Germany. In all these cases what the central governments have appropriated for waterway improvements is only a part of the total amount expended. In the United States, for instance, about $214,000,000 have have been spent upon canals by States and corporations.*

*Census Report, Transportation by Water in 1906, p. 44.

The increase of traffic on the waterways of Europe in contrast with the decline on many streams of the United States is due, in part at least, to the very great difference between conditions in Europe and those in the United States, of which the following are, it is believed, the most important:

1. Difference in density of population.—The United States is much less densely populated than Europe. In 1909 the population was estimated at 46 inhabitants per square mile for the entire United States, while for entire Europe it was approximately 107. In Germany the population is 290 per square mile, and in Belgium it is 620. The greater density of population in Europe tends to increase the quantity of freight in a given area, though this statement must be made with some limitations, due to the lower average of consumption and the less degree of industrial activity in some parts of Europe. At the same time it is a notable fact that the railway mileage per square mile in the United States, at least in the settled portions, is equal to or greater than that in Europe, while the entire mileage per thousand of population is five times as great, thereby showing that the United States is much more adequately furnished with means for railway transportation.

2. The earlier development and greater relative advantages of waterway systems in Europe.—In Europe the waterways were developed and in very general use before the introduction of railways. Factories, as well as warehouses, were located with reference to such waterways, and great reliance was placed upon waterway transportation as a means of industrial growth. The European waterways were constructed in many cases at a time when the question at issue was only between transportation by wagons and by boats; and consequently the European railway systems constructed at a later date were not developed to the same degree of efficiency as those in America. It is also more difficult to provide railways in Europe because of the very high cost of rights of way; and in this connection the opportunity for betterments in the way of eliminating grades and curves is much less in Europe than in America. The carrying capacity of the European freight car is but a fraction of that in the United States.

3. Trade movement.—Another difference as compared with the United States is the greater fixedness in Europe in the location of manufacturing cities as well as in the lines of distribution of raw material due to the earlier development of coal mines and other sources of material. The shifting of the centers of production which arises from the development of new coal mines and new centers of manufacturing, as well as from the great growth of population, is much less common in Europe than in the United States. This makes it possible to utilize an established waterway with a greater assurance of profit and with greater dependence upon it as a means of transportation.

4. Habits and customs.—One social condition, entitled to very considerable weight, is the existence in Europe of a class of boatmen who, for generation after generation, apply themselves to the handling of boats in river or canal traffic. These boatmen live with great economy upon the canal boat and seem to be contented with comparatively small gains and with conditions which would not be regarded favorably in the United States. In most cases towage is accomplished by horses, which are often stabled in the boats, but in numerous instances canal boats are towed by men. Steam and electric traction is restricted mainly to large boats and trains of tows.

5. Engineering difficulties.—Engineering difficulties, as a rule, on those rivers which are most utilized, are less serious on the rivers of Europe than in the United States. The most notable example of this is the River Rhine. Its sources are in the Alps, where the melting of snow and ice during the hot weather of summer furnishes a constant supply for the water flow of the river at the very season when rivers are likely to be lowest in the United States. Furthermore, it should be said that conditions as regards alluvial banks, and shifting bars due to deposits of silt, are on the whole more favorable to river improvement in Europe than in the United States, and especially so upon rivers whose improvement would be most useful.

6. The different relations between railways and waterways.—Military considerations have been much more regarded in Europe, not only in the construction but in the management of transportation lines, than in the United States. Railways are laid down to connect the center with the frontier, or, at any rate, are located with a view to the mobilization of troops and to the carrying of supplies to places where they may be needed, and with a less uniform regard for serving great manufacturing centers or populous cities. Waterways are located mainly with a view to the development of trade at all times and to relieving the railroads in time of war.

Sedulous care is taken by most European countries for the protection of inland water-borne traffic against railway competition. In France this is accomplished by enforcing a differential of 20% in favor of the waterways as against railways, with the evident intention of maintaining both methods of transportation. In a majority of the other countries in which water transportation has reached its highest development the railways wholly or partially belong to the state. This is true in Germany, Austria, Hungary, Holland, and Belgium. The well-established policy in these countries is to secure cooperation between railways and waterways by official control of railway rates, with a view to maintaining profitable traffic on the latter.

In 1906 the length of the railways of the United States was 222,571 miles, about 7.7 times the estimated length of all its navigable canals and rivers. The total tonnage of the railways in 1904 amounted to 1,631,374,219 tons. This was 12.3 times the estimated traffic of all the navigable rivers and canals in the United States, amounting to 132,000,000 tons.*

The success of water transportation in Europe is often attributed to the fact that railroad rates are higher abroad than in the United States. In a later report, the commission will endeavor to set forth a careful comparison between the freight and passenger rates of European countries and those of the United States. Frequent errors have been made in the past in comparing the average rates per ton per mile, owing to the different methods of handling traffic and of determining rates, resulting in erroneous and confusing conclusions. In Belgium, for instance, the cost of collection and delivery is included in the railroad rate, while in England such freight as is carried by express companies in this country is carried by the railroads directly. The average length of haul in this country is far greater than in Europe, owing, in some measure, to the smaller political divisions abroad. This tends to reduce the average cost per mile in this country. A proper comparison must be between specific commodities carried for specific distances, and under similar regulations as to the method of handling, and must take into account the comparative cost and effectiveness of labor, and also the cost of materials used, in the two cases.

Moreover, the railroads of Europe realize a much larger share of revenue from passenger traffic. Consequently, on the majority of their lines a greater degree of attention is paid to the handling of fast passenger trains, and this necessarily diminishes the efficiency of freight service. It has been stated in a document transmitted to the commission that the average time during which a freight train is operated in Prussia is only three hours per day, the cars being on sidetracks and in yards the remaining twenty-one hours. It should be conceded in this connection, however, that in some cases the efficiency of freight service and the number of hours of actual running time per day is no greater in the United States than in Europe.

While recognizing the necessity of more thorough investigations of the results of all these different factors, the commission would call attention to the fact that the average European freight rates on railway lines paralleling water routes, especially for short distances, are higher than those on lines similarly situated in the United States, and also that the European rates for water-borne carriage, in some instances even where the traffic is very large, are as high or higher than on railways in the United States in localities where traffic is likewise large.

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*W. J. McGee, Our Inland Waterways, in Popular Science Monthly, April, 1908.

Progress of Excavation and Construction on the Panama Canal.

"The Canal Record" for Jan. 12, 1910, contains the usual tabulation of excavation and construction work on the Panama Canal during the calendar year just past. From that tabulation we have abstracted certain figures which we give herewith, together with our own diagrams of the present state of the excavation. During last year the Isthmian Canal Commission changed its system of excavation accounting in such fashion that it is impossible to collate from the detailed and collected reports any accurate statement of monthly progress, mainly because of the difficulty of assigning to their proper places the

TABLE I.—SHOWS THE FOLLOWING FIGURES FOR THE EXCAVATION OF EACH OF THE SIX CALENDAR YEARS:

Year.	Cubic Yards. Dry.	Wet.	Total
1904*	243,472	.....	243,472
1905	914,254	884,973	1,799,227
1906	2,729,619	2,218,878	4,948,497
1907	10,961,162	4,804,128	15,765,290
1908	22,309,131	14,807,604	37,116,735
1909	21,067,664	14,028,502	35,096,166
Total	58,225,302	36,744,085	94,969,387
Remaining	42,061,682	36,635,525	79,697,207

*From May 4 to December 31, 1904.

accounts for excavation within and without the canal prism, respectively. We cannot, therefore, give a tabulated statement of monthly progress, as we did at the end of 1908 (Eng. News, Jan. 14, 1909, p. 51), but must restrict the account to annual amounts.

The general statement of the progress of the work is as follows:

The grand total of excavation in 1909 was 35,096,166 cu. yds. This was 2,020,569 cu. yds. less than the grand total of 1908, for the reason that the field of operations in dry excavation had been narrowed by the completion of the work in certain sections, and because in wet excavation the dredges encountered more difficult conditions. While 1908 will stand in the record of canal work as the banner year, the highest point touched in a single month was that of March, 1909, when for the first and only time the four million cubic yard limit was reached and passed with a total of 4,062,632 cu. yds., including 182,295 cu. yds. of "plant" excavation.

The falling off in excavation in 1909 from the total of 1908 was 1,241,467 cu. yds. in dry excavation work, and 779,102 cu. yds. in dredging.

Of the total dry excavation in 1909, there were taken out in the territory of the Central Division, which includes Culebra Cut and the Gatun Lake region, 18,299,526 cu. yds. The increase in the effectiveness of the steam shovel work is seen from the following comparison of the excavation per shovel day in 1908 and 1909:

The work is affected by the rainy season from May to December.

In Culebra Cut, where the excavation was continued on practically the same scale as in 1908, the amount excavated was 14,579,838 cu. yds. in 1909, as compared with 13,914,326 cu. yds. in 1908. Although it is considered that the maximum excavation in the cut is that of March, 1909, it is also expected that there will be little, if any, falling off in the total excavation in this part of the work during the present year. The work of widening the channel between Las Cascadas and Paraiso, a distance of four and one-half miles, from 200 to 300 ft. at the bottom, was authorized in Oct., 1908, and during 1909, the excavation was carried on with this end in view. The consequent opening up of new banks caused a number of slides that were a source of inconvenience during the rainy season. The completion of the drainage system by opening the Obispo Diversion and installing pumps at Bas Obispo was another feature of the work in Culebra Cut during 1909.

At the Atlantic and Pacific entrances to the canal the dredges have made, but not completed, a channel over five miles into the land, and the Pacific entrance was so far advanced on Feb. 1 that steamships began to use that portion of the canal.

At Gatun Locks, the preparatory work of installing the concrete mixing and handling plant was completed, and the laying of concrete with the permanent plant was begun on Aug. 24. Since then there has been a steady increase in the amount of concrete laid each week, due to increasing effectiveness in the plant and in its operation. Up to the close of the year, 116,186 cu. yds. of concrete had been laid, and the daily average had increased from 459 cu. yds. in September, to 1,672 cu. yds. in December, while in one instance over 2,000 cu. yds. were placed in one day of 12 hours. The estimated amount of concrete necessary for completing these locks is 2,096,000 cu. yds.

The hydraulic fill between the rock toes of Gatun Dam was begun on Dec. 24, 1908, and the results accomplished in this work belong, therefore, to the year 1909. From one to three 20-in. suction dredges have been engaged and they have pumped 2,044,992 cu. yds. of selected material into the dam. The dry fill now amounts to 2,515,524 cu. yds., the total being 4,560,516 cu. yds. The estimated fill to be made by the hydraulic method is 20,000,000 cu. yds. On Feb. 17, 1909, by order of President Roosevelt, the proposed height of the dam was reduced from 135 ft. above sea level to 115 ft., which will make the top 35 ft. above the normal level of the water impounded in Gatun Lake.

One week after the laying of concrete, with the permanent plant, was begun at Gatun Locks, a temporary plant was put in operation at Pedro Miguel and the laying of concrete in the locks at that point was begun. This temporary plant laid 33,994 cu. yds. of concrete between Sept. 1, and Dec. 31. The estimated amount to be placed at this point is 922,600 cu. yds. Work on the cantilever cranes for the permanent handling plant is in progress. The construction of the earth dam at Pedro Miguel was continued during part of the year.

At Miraflores, excavation in the upper lock chamber was practically completed during the year; excavation in the lower lock chamber was continued, and the work of building storage trestles for the cantilever concrete mixing and handling plant was begun. A total of 557,587 cu. yds. of filling had been placed in the dam at Miraflores Locks up to Dec. 31.

It will be noticed by comparing the figures for the amount of work yet to be done in Table I. with those given in previous records, particularly those given in our summary of last year (Eng. News, Jan. 14, 1909, p. 51), that there are serious discrepancies in the totals. Thus at the end of 1908, it was stated that 182,000,000 cu. yds. was estimated to be the total amount necessary to be removed in 1904, and of that amount, the French had removed 40,000,000 cu. yds. and the Americans 60,000,000 cu. yds., leaving 82,000,000 cu. yds. to be excavated on Jan. 1, 1909. Now, on Jan. 1, 1910, it is stated that 79,000,000 cu. yds. is yet to be removed, although 35,000,000 cu. yds. were taken out during 1909. This discrepancy is due to two things, (1) the increase in the estimate of the necessary excavation by the widening of the Culebra cut and by certain other changes in section and, (2), a revised estimate of the French excavation, which reduces the useful work done by the original companies to 29,908,000 cu. yds. Thus the present figures, brought to Jan. 1, 1910, are:

Total French useful excavation	29,908,000
Total American excavation	94,969,387
Total future excavation	79,697,207
Total estimated excavation	204,574,594

These figures have been graphically shown in Fig. 2. According to this estimate, the French did 14.6% of the excavation, the Americans have done 46.4% and there is still 39.0% to be done.

Fig. 1 is a graphical representation of the progress of the American excavation since 1904. About 55% of the work of excavation has been performed.

TABLE II.

Month.	1908. No. shovels at work.	1908. Cu. yds. per shovel day.	1909. Shovels at work.	1909. Cu. yds. per shovel day.
January	51.53	1,040	51.80	1,183
February	54.00	1,112	56.05	1,260
March	53.65	1,159	56.93	1,368
April	53.04	1,191	55.40	1,284
May	53.24	905	50.60	1,185
June	55.15	1,011	45.65	1,243
July	52.58	1,071	45.08	1,207
August	52.58	1,123	46.73	1,133
September	49.68	1,180	46.60	1,248
October	49.55	1,185	47.23	1,230
November	50.91	1,155	41.75	1,161
December	50.73	1,210	43.15	1,123

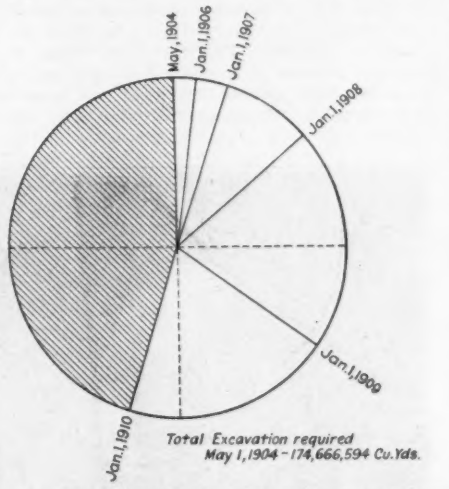


Fig. 1. Diagram Showing Progress of American Excavation on the Panama Canal.

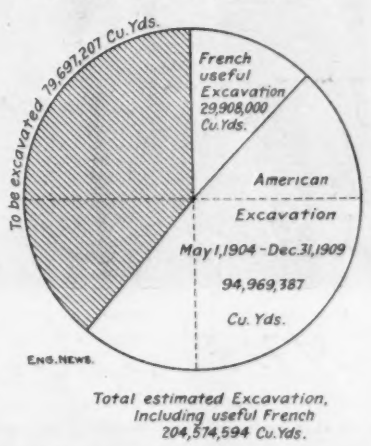


Fig. 2. Diagram Showing Relation of French and American Excavation on the Panama Canal.

Annual Meeting of the Canadian Society of Civil Engineers.

The 24th annual meeting of the Canadian Society of Civil Engineers was held last week at Ottawa, Ont., and was one of the most largely attended and successful meetings the Society has ever held. The total number registered was about 225. A local committee from the Ottawa Branch of the Society was notably successful in its provision for the reception and entertainment of the visitors. The sessions were held in the City Council Chamber by courtesy of the city officials of Ottawa. The social features included a luncheon tendered to the visitors by the Ottawa Branch on Tuesday, a smoker on Tuesday evening at which the President, Mr. Geo. A. Mountain, Chief Engineer of the Railway Commission, delivered the annual address, and the annual dinner, held at the Russell House on Wednesday evening.

The annual report of the Society's Council shows that the total membership is now 2,569, of which 1,165 are in the Student grade. The Society's financial statement shows a total income last year of about $13,000. Branches of the Society are now organized in Winnipeg, Toronto, Ottawa, Quebec and Vancouver. Besides the "General" Section, the Society has organized an Electrical Section, a Mechanical Section and a Mining Section.

Much of the time of the meeting was devoted to the reports of committees. One of these was on the establishment of a Government testing laboratory. The committee had visited Hon. Wm. Pugsley, Minister of Public Works, and urged the establishment of such a laboratory. The committee was continued with instructions to appeal to the Government for the appointment of a Commission to visit Government testing laboratories in the United States and elsewhere and investigate the desirability of similar laboratories in Canada.

A committee on Transportation Routes, of which Mr. W. F. Tye, of Montreal, is Chairman, submitted a brief progress report, and on its request was continued. The object of the committee is to investigate the methods by which the most economical transportation may be secured over the long distances lying between the vast area of productive farms of the Canadian Northwest and the markets and shipping points of eastern Canada.

In presenting the progress report, Mr. C. R. Coutlee explained that the committee was endeavoring to compare transportation routes on the basis of the actual cost of transportation, whether by rail or by water. The committee had found that those who make freight rates know nothing about the cost of transportation. They base their rates on what the traffic will bear.

The committee on rails described the new standard drop-testing machine, in which the anvil is mounted on springs, and expressed the opinion that the new machine would lead to much better knowledge of the character of rails subjected to test.

The committee on standard methods of testing cement, of which Mr. J. A. Jamieson is Chairman, reported that no changes are at present considered advisable in the standard submitted at the annual meeting a year ago. There was an extended discussion on this report and the committee was authorized to make a further report as to proper specifications for sand.

A committee was appointed to formulate standard specifications for cast-iron water pipe. A committee was also appointed on the Conservation of Natural Resources, the appointment being made at the request of Hon. Clifford Sifton, who is at the head of the new Dominion Government Commission on Conservation just created.

The most important committee created, however, was one which has for its object to secure the reorganization of the Government engineering service on a permanent basis, under which those in the service will have more adequate compensation and more security in their positions and a better grade of engineering talent will be at the service of the Government. Investigation will probably be made of the engineering service of the Indian and Australian Governments. The Chairman of this committee is Mr. Henry Holgate, of Montreal.

One of the most interesting features of the meeting was the presence of Sir Sanford Fleming, one of the oldest and most distinguished of Canadian engineers. Sir Sanford in welcoming the Society to Ottawa said:

> I have been a resident of this city for a great many years—so many that I almost forget the number—since before Confederation, and that is now over forty years. I can go back no less than fifty-five years to my first sight of Ottawa. It had not then even the name of Ottawa; it was called Bytown. I am an old member of this society, and of the sister American society. For nearly half a century I have been a member of the American Society of Civil Engineers. Not quite so long as that a member of this society, for it has not been in existence that length of time.

Mr. Thos. C. Keefer, the first President of the Society and Past-President of the American Society of Civil Engineers, was expected to address the Society, but was unable to be present on account of the long stairs leading into the City Council Chamber. Mr. Keefer still enjoys a good degree of health although well past 80 years of age.

Wednesday was given up to excursions about Ottawa. Of particular interest to the visitors were the power plants at the Chaudiere Falls of the Ottawa, where some 30,000 HP. is now available at low water. This will be increased when the storage reservoirs on the upper Ottawa are completed to about 80,000 HP. The power, which up to 1900 was chiefly used for sawing lumber, is now developing electric power for use in Ottawa and driving the large paper mills of J. R. Booth, where about 100 tons a day of paper are turned out.

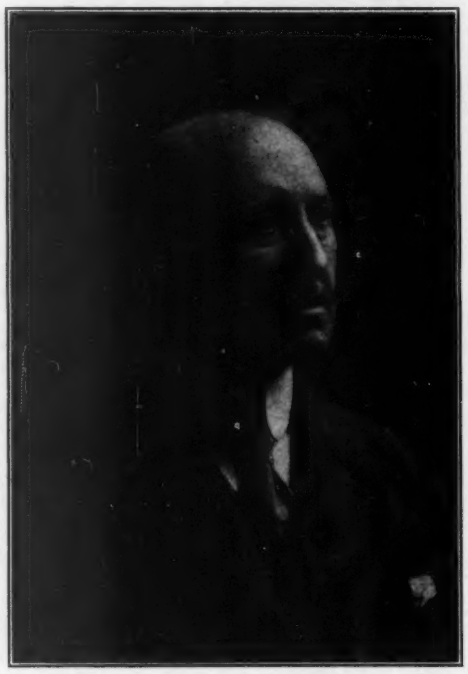
Rapid progress is being made on the fine new railway station and the new hotel which are expected to add much to the attractiveness of the city to tourists and to those seeking homes in the Canadian capital.

H. N. Ruttan, President of the Canadian Society of Civil Engineers.

The new President of the Canadian Society of Civil Engineers, elected by the ballot which was canvassed at the Ottawa meeting last week, is Lieut.-Col. H. N. Ruttan, who has been City Engineer of Winnipeg, Manitoba, for 25 years and is one of the best known and most highly respected engineers in Canada. Col. Ruttan began his engineering work in the railway service, his first position being under Mr. E. P. Hannaford, Chief Engineer of the Grand Trunk Ry. When the construction of the Intercolonial Ry. began, Mr. Ruttan was employed upon it as a junior in the staff of Sir Sandford Fleming, the Chief Engineer. He remained on this work, first as assistant engineer and later as division engineer, until the construction was practically completed. It was here that he obtained his first experience in the management of construction work. On Section 6 of the road, the original contractors gave up their contract and the work was finished by the Government, with Mr. Ruttan as the manager of construction.

When the Canadian Pacific Railway was first projected, Mr. Ruttan was placed in charge of a party which made the first surveys in 1875 along the shore of Lake Superior between the Pic and Nepigon rivers. In the following year, 1876, he was sent to the Far Northwest and placed in charge of a party which made first the preliminary and later the location survey between Edmonton and the Yellow Head Pass. On this work he spent nearly two years. In 1877, while the construction work on the Canadian Pacific was going on, Mr. Ruttan was employed as contractors' engineer by Mr. Joseph Whitehead on Contract 15, between Cross Lake and Rat Portage. Here he had charge of both the engineering and the construction cost departments. In 1880, Col. Ruttan took up his residence in Winnipeg and went into business on his own account as an engineer and contractor. Between 1880 and 1883 he constructed the present Canadian Pacific Ry. line between Portage La Prairie and Gladstone. He also built the Canadian Pacific Ry. Southwestern between Winnipeg and Carman.

In 1883 Col. Ruttan took up the study of municipal engineering problems, and spent the next two years in close examination of engineering work in various cities of the United States. Following this, in 1885 he was appointed City Engineer of Winnipeg, which was then a straggling frontier town with a population of about 16,000. The present population, 25 years after, is estimated at 150,000. The municipal works of the city are abreast of the best American city practice, and they are all practically the creation of Col. Ruttan. Particularly noteworthy is his



H. N. Ruttan

work in the creation of the water-supply system. The domestic supply of the city is obtained from seven artesian wells, each of which has an output of three-quarters of a million to five million gallons per day. There is also a special fire-protection system supplied by pumps with a capacity of 9,000 gals. per minute, delivering water at a pressure of 300 lbs. per square inch. The cast-iron mains for this high-pressure fire service have a total extent of eight miles through the business district of the city. The city is now constructing a hydro-electric plant for the supply of light and power on the Winnipeg River. The Chief Engineer of this work is Mr. C. B. Smith, and Col. Ruttan is a member of the Consulting Board of Engineers in connection with the work, the other members being Mr. William Kennedy, Jr., and Prof. L. A. Herdt, of Montreal.

Col. Ruttan was prominent in the movement which led to the organization of the Canadian Society of Civil Engineers in 1887, and is a charter member of the Society. He also holds membership in the Institution of Civil Engineers of Great Britain, the American Society of Civil Engineers, the American Water Works Association, the American Society of Municipal Improvements, and the Concrete Institute of Great Britain.

The Water Supply, Sewerage and Subways of Paris in Relation to the Present Floods.

By GEO. A. SOPER,* Ph. D., M. Am. Soc. C. E.

Continued rains and snows have caused floods in France which have produced unprecedented damage in that country. It is still too early to estimate the extent of the destruction, and it will probably be several weeks before an accurate idea can be obtained as to the full amount of suffering, loss of life and injury to public and private property. At the present writing communication with the affected districts is practically suspended, excepting in the case of Paris, where the ravages of the overflowing Seine cause interest to center.

Besides enormous damage to other property in Paris the floods are reported to have wrought havoc with the water-supply distribution system, the sewerage system and portions of the sewage-disposal works and with the underground and surface railway systems. Very little definite information as to the nature and extent of this damage is yet available, but the situation that has confronted and still confronts the city renders of special interest, just now the engineering works mentioned, and notably the parts of them which are underground. The Paris sewers, in particular, are of unusual significance at flood juncture, because they accommodate water and gas mains and cables for electric wires. Before taking up the sewers, water supply and subways a few words may be said on the Seine itself.

Hydrology of the Seine.

Paris is 115 miles from the sea, measured in a direct line, but by the winding channel of the river the distance is 226 miles. The fourth largest river in France, the Seine, drains 30,370 sq. mi. of country, and is navigable for 350 miles from its mouth. In its natural condition the tide flowed 19 miles from Rouen. Locks constructed at Martot, 15½ miles above Rouen, now limit the tidal run to 93 miles from the sea.

The Seine from Paris to the English channel affords an excellent illustration of the extent to which a river, not naturally adapted to the requirements of modern commerce, can be improved by engineering works in the interests of navigation and trade. Because of the improvements which have been made to increase the carrying capacity of this stream, ships drawing about 20 ft. of water are able to reach Rouen, barges carrying from 800 to 1,000 tons can reach Paris, and steamers of 300 tons burden trade regularly between that city and London.

Notwithstanding its improved condition for the purposes of navigation, the Seine is subject to frequent and rapid rises, with all the inconveniences, not to say dangers, which this means. There have been 46 overflows of the Seine at Paris in the last 200 years. The average discharge of water at the mouth of the Seine is estimated at 17,118 cu. ft. per sec., the low-water discharge is 9,180 cu. ft., and the maximum in flood is 78,290 cu. ft. By comparison it is interesting to note that the drainage area of the Seine is a little more than twice that of the Hudson River, and its average discharge is a little less than three-fourths that of the Hudson. The relation of the Seine to the other rivers of Paris is shown by Fig. 1, which also gives the areas of recent excessive rainfall. Fig. 2 is a contour map of Paris showing flooded areas within that city.

At Paris the Seine is entrained between masonry walls, the latter being on a level with the surrounding streets and the river at normal stages being about 20 ft. below. The stream flows through the busiest and most beautiful parts of the city, entering near the southeast border, penetrating to near the center, and flowing away in a southwesterly direction. Notwithstanding the walls which have been built to confine the Seine at Paris, the situation of the city with regard to the stream may be said to invite trouble. After making a right-angled turn within the city limits, the stream enters upon a series of re-

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markable bends through which it travels over 35 miles in reaching a point within a dozen miles of its place of departure. The effect of this doubling must be seriously to limit the capacity of the river to accommodate itself to sudden accessions of volume such as have recently occurred. Figs. 3 to 6 show views of the Seine and vicinity.

The Seine within the limits of Paris is to some extent obstructed by 2 islands and 26 bridges. Many of these bridges are of massive masonry

Fig. 1. Sketch-Map Showing River-Systems of France; Excessive Precipitation.

construction, with arches and piers, although some cross the stream in a single graceful span. The largest and handsomest is the Pont Alexandre Trois. It is a single, flat steel arch, 352 ft. long and 130 ft. wide. During the flood the water rose to such a point on some of the bridges that it seemed probable they would have to be blown up with dynamite in order to prevent them from damming the waters back upon the city on each side of the river. The piers of the bridges and submerged ends of the arches must have offered considerable obstruction to the stream, once it rose to dangerous proportions, and aggravated the difficulty with which the water could flow away. This difficulty appears to have been materially increased by quantities of driftwood which were carried down from the outlying country, large areas of which were inundated.

At low water during dry seasons the discharge is about 1,500 ft. per sec. At the height of the flood the river is said to have raised about 25 ft. above mean water mark and flowed at the rate of 25 mi. per hr. in places.

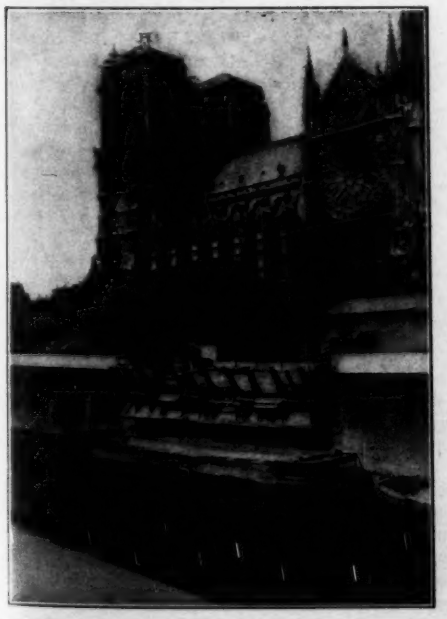


Fig. 3. View of the Seine and the Cathedral of Notre Dame, Showing Chutes for the Loading of River-Barges.

The commerce upon the river affords a ceaseless panorama of interest to foreigners. Besides the shipping employed in the handling of merchandise, regular lines of passenger steamers ply busily from one end of the city to the other, making frequent stops at regular landing stages and wasting surprisingly little time in letting off and taking on passengers. At the up-stream end of the city, near where the Marne and Seine unite, many parties of fishermen are to be seen in summer sitting in small boats anchored in midstream angling with rod and line beneath the shade of large umbrellas. In other parts of the city bathing establishments and large laundry houses are located in the river.

Subterranean Structures.

A trip on the Seine gives a glimpse of what is now of peculiar interest—the subterranean labyrinths of Paris. Conspicuous upon the left bank is a series of open arches just below the level of the street, where the line of the Orlèan railway runs to unite Paris with the cities of Orleans, Bordeaux, Tours and places in Spain. This railroad penetrates along the left bank of the Seine underground to the depot know as Gare du Quai d'Orsay, near the newest and most attractive residence district of the city. Press despatches indicate that the Seine has overflowed this subway and caused some of the overlying streets to cave in upon it. Farther back from the river and apparently untouched by the flood are extensive ancient underground quarries converted into catacombs and containing the bones of nearly six million persons. Passenger subways and sewers, the latter carrying, besides its stream of waste, the double water-supply of the city as well as telegraph, telephone, gas and pneumatic mail service, make a labyrinthian network under ground, the flooding of which might well give rise to consternation. (See Fig. 11 for sewer sections.)

The flooded area of Paris lies on both sides of the Seine, and runs back in places to a considerable distance from the river. The total area inundated is reported as 9 sq. mi. within the city limits. According to the same source one-quarter of the city is under water. There is obviously an error in the news, for the area of the city is 30.1 sq. mi., of which about one-tenth is ordinarily occupied by the river; so that if the inundated territory was 9 sq. mi., about one-third of the city would be flooded. A study of the contours shown on government maps makes it seem highly improbable that one-third of the city has been overflowed. (See Fig. 2.)

A consideration of the height of the land with reference to the river will dispel at once the idea that the flood has threatened the existence of Paris or made its total submergence imminent, as reports have indicated. Paris lies 80 ft. above the sea at the lowest point (Grenelle) and 420 ft. at the highest (Montmartre). High land lies at the south, east, north and west within the city, in area sufficient to accommodate such refugees as may need its temporary protection. Over half the land to the north and south of the flooded area lies more than 15 ft. above the highest point reached by the waters.

Population and City Plan.

The city of Paris affords an interesting example of the remarkable enterprise and progress which many European cities have made in recent times to overcome defects of plan and prepare for a better and more enlightened growth. One hundred years ago the population was about 700,000, and in 1852 it was about 1,000,000. In the next 18 years under Emperor Napoleon III. the city experienced a transformation. The fortifications were torn down and rebuilt farther away in order to give the city more room to grow. On the site of the old walls, broad boulevards, with trees and graveled walks, were constructed; dense masses of houses and crooked highways were taken away and replaced by well-considered streets; beautiful and serviceable buildings, parks and open spaces made their appearance. The Paris of to-day is the creation of Haussmann, whom Napoleon appointed Prefect of the Seine, and of Belgrand and other engineering geniuses who were called upon to assist him. The work done to carry out the plan of development is estimated to have cost upward of $250,000,000 to 1870, and the annual cost of work along these lines has averaged over $4,000,000 for the last 28 years. The general street system of Paris is shown by Fig. 7.

It has been well said that the streets of Paris are the homes of the people. Certainly in no other city is so much time spent in business and pleasure upon the streets as here. It is not

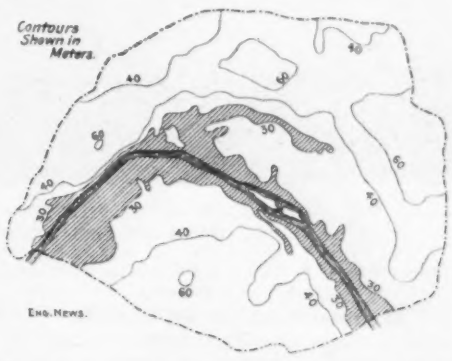


Fig. 2. Contour-Map of Paris, Showing Flooded Areas.

strange, therefore, that the sanitary care of the streets should have been for more than 50 years one of the principal concerns of the municipal authorities.

Returning to the question of population, it is interesting to consider how the growth of the city has justified the provisions made for it. The inhabitants, who numbered about 1,000,000 in 1852, numbered 1,525,255 in the year 1860, after the limits of the city had been extended and some suburbs, including 558,000 persons, had been incorporated. Ten years later the population was 1,825,274. In the year 1901 the population had increased to 2,714,068. At the last census, 1906, the population was found to be 2,763,393, including about 250,000 foreigners. Paris has, therefore, nearly doubled in the 50 years since its transformation.

The number of houses within the limits of Paris was 79,159 in the year 1906. There were 86,203 houses supplied with spring water, and 16,981 of these were supplied withh river water also. River water is not supplied to houses unless they are already connected with the spring water-supply. The number of houses connected

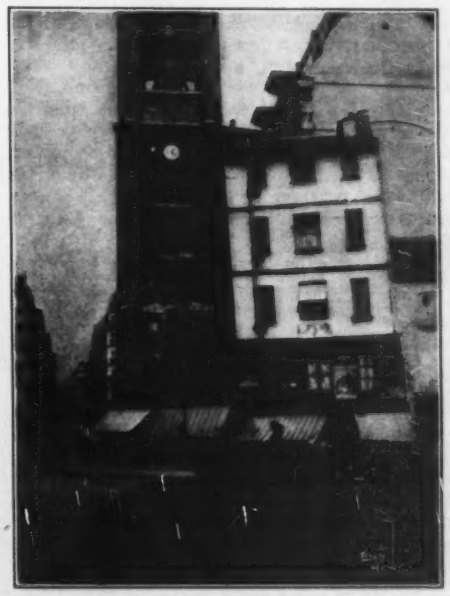


Fig. 4. View in the Old Section near the Left Bank of the Seine, Now Flooded.

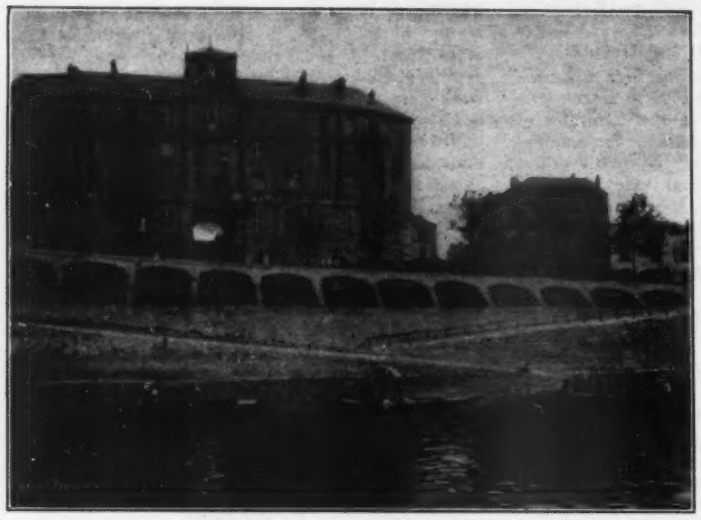


FIG. 5. THE SEINE SOON AFTER ENTERING PARIS, SHOWING INCLINED MASONRY EMBANKMENTS.

with sewers was 41,995, or a little more than one-half the total number of buildings.

The Dual Water-Supply of Paris.

Paris is unique among great cities in possessing two separate and complete systems of water-supply. (See Figs. 8 and 9.) By the first, spring water is brought by gravity, in covered aqueducts, and filtered river water, raised by pumping, is supplied to the houses for drinking purposes. By the second system, river water is obtained by gravity, or raised by hydraulic or steam pumps, for other uses than those for which the water of the first system is employed; that is, for washing the streets, flushing the sewers, sprinkling gardens, and flushing water-closets. The sources of spring water lie from 50 to 75 miles to the east, west and south of Paris.

The river water-supplies of Paris (Fig. 9), which are obtained from the Marne and Seine, are pumped in the suburbs near the confluence of these two streams. The Seine water is purified at Ivry by the Puech system of filtration, which, introduced in very recent years, has had considerable success on the Continent and has been employed to treat a part of the London water-supply. (See Eng. News, March 28, 1908.) Two main principles are incorporated in the Puech system; thorough aeration and double filtration. The water is aerated by passing over small cascades. It is filtered first through gravel and then sand. In these filters, constructed in 1899 and recently rebuilt, considerable head has been saved by substituting for the drain-tile gravel system, customary at the bottom of sand filters, low-grade, porous concrete slabs as a support for the filtering material. The capacity of the filters at Ivry is 18,500,000 gals. per day.

At St. Maur on the banks of the Marne, sand filters are employed after the practice which is familiar to most engineers. The capacity of these filters is 6,600,000 gals. per day. At St. Maur, prolonged experiments have been made upon the sterilization of water by ozone and other means. Here Baron Tyndall erected an ozone plant in 1900.

The Vanne is the largest and most important aqueduct. It brings over 27,000,000 gals. of water to Paris each day over a distance of 107 miles. This water is received in a covered reservoir and distributed to the consumers without sensible change in temperature and without seeing the light of day from the time it leaves its source.

The drinking water is supplied under considerably more pressure than the washing water, so that it is customarily used as power for elevators and for standpipes for fire purposes. The average consumption of water in Paris is 23 gals. per capita of drinking water and 46 gals. per capita of wash water, based on the assumption that every person in the city is a consumer. The total quantity of water supplied is about 200,000,000 gals. per day.

The accompanying table shows the consumption of water from the various sources.

The water is distributed, as far as practicable, by pipes placed in the sewers. The double system in 1906 had a total length of 1,643 miles, which is a little more than twice the length of the sewers. In the year mentioned there were 8,400 hydrants to supply water for cleaning the streets, 7,458 fire hydrants, 7,709 hydrants for sprinkling the streets, 1,539 public urinal connections, and two public fountains each of which consumed from 12,000 to 16,000 gals. per min.

The consumption would doubtless be much larger if more houses were connected with the sewers in the usual way, if water closets and bath-tubs were more common, and if the pressure was greater. It is already large as compared with other foreign cities, a fact which must be attributed to the great amount of water used in cleaning the streets.

PUBLIC WATER SUPPLIES OF PARIS.

Sourse of water.	Gallons per day in 1906.
For Drinking—	
Spring Water:	
Dhuis	4,371,510
Vanne	27,590,406
Avre	21,949,736
Luing and Lunain	9,520,768
Filtered River Water:	
Seine	52,842
Marne	0
Total	63,485,262
For Washing—	
Ourc	32,398,786
Seine	70,589,524
Marne	23,020,746
Wells and old aqueducts	2,129,440
Total	128,138,498
Grand total	191,623,760

Fig. 6. View of the Seine Just Before Leaving Paris.

central principle, as tout à l'égout. In brief, the sewers are intended to collect whatever refuse can be carried into them by water from the streets and houses. The sewage is conducted to a central station situated on the banks of the Seine a few miles from Paris where, by means of pumps, siphons and aqueducts, it is carried to farm lands for disposal. The first large sewer of this system has been in use since 1861.

By a law passed in 1896 householders are compelled to make connections with the sewers as rapidly as the lateral sewers are constructed and the plumbing of the houses can be arranged. There is often considerable difficulty in devising proper plumbing for the houses, many of which are very old. Many of the houses which are not connected with sewers are provided with cesspools.

The cleaning of cesspools, which are very commonly employed in European cities for the reception of excrement, has been elevated to a point of technical perfection in Paris. Movable pumping machinery and tank wagons are employed here as elsewhere, but so cleanly, orderly, noiselessly, odorlessly and expeditiously is the operation performed that it can be carried on even in a crowded street without causing offence. In spite of this, however, the existence of cesspools in crowded cities is not approved of, and

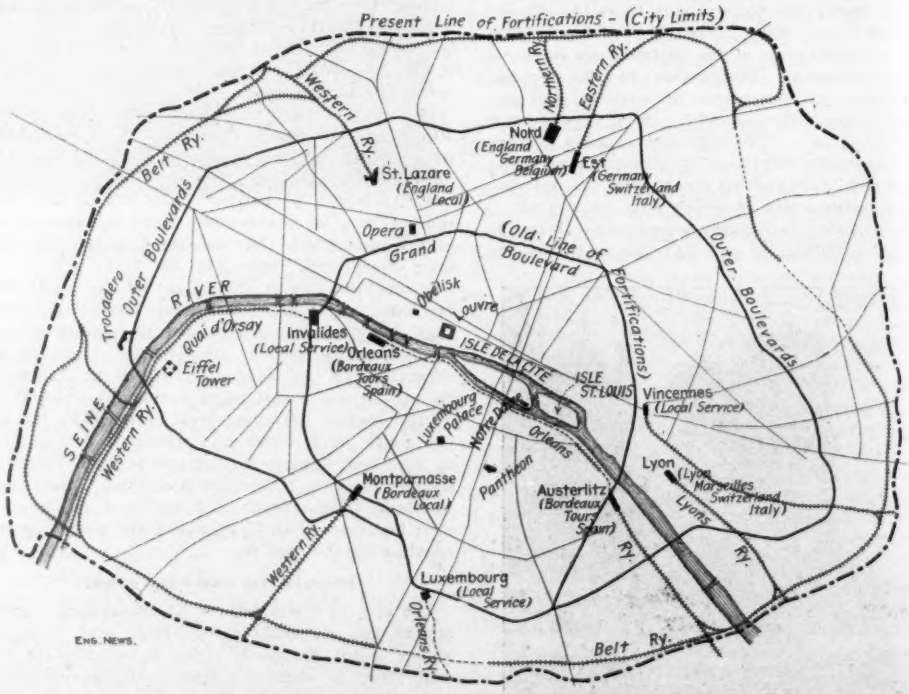


FIG. 7. GENERAL MAP OF PARIS, SHOWING SYSTEM OF PRINCIPAL STREETS, TRUNK LINE TERMINALS, AND POINTS OF INTEREST.

The Sewers.

The sewers of Paris are intended to accommodate storm water and the drainage of the houses (Figs. 10 and 11). The system is known, by its

the number of houses which are giving them up for direct sewer connections is increasing.

Beside the houses which have direct connections with sewers there are, roundly, 13,000 which have indirect connections of a special sort. These connections, like the cesspools, were devised before the present system of sewerage was installed and are being replaced as rapidly as practicable. The connection consists essentially of a filter which receives the solid and liquid excrement that must be disposed of. It allows the liquid to flow away to the sewers and retains the solids, which are removed by carts as often as necessary.

The total length of the sewers of Paris on Jan. 1, 1907, was close to 700 miles. The streets where sewer connections with houses was compulsory contained 502 miles of sewers. Of the total length of the sewers 64 miles were 4 ft. or more in diameter. The small sewers usually lie within 10 or 12 ft. of the surface, but the large ones vary from 20 to 140 ft. below ground.

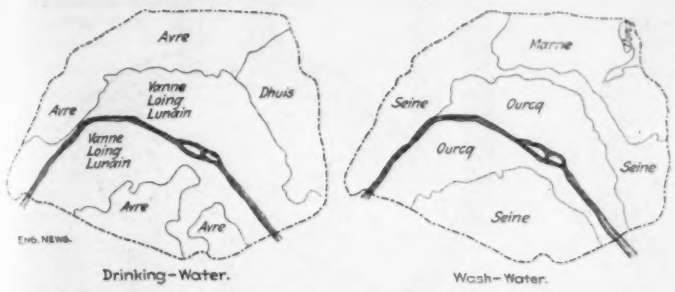


FIG. 8. ZONES OF DISTRIBUTION OF DRINKING WATER AND WASH WATER IN THE CITY OF PARIS.

A visit to the sewers has, since the first great sewer was built, about fifty years ago, been considered one of the sights of the city. The trip may be made without the least inconvenience. In fact, the arrangements might almost be said to be luxurious. Parties are met by the management and are conducted by well-informed guides, who point out the principal matters of interest. During one of the international exhibitions at Paris it was not uncommon for 600 visitors to be present in the sewers at one time. The route is brilliantly lighted by electric lamps.

The sewers have no catch basins (Fig. 11), and the custom of washing into the gutters solid matter from the streets, makes it necessary continually to clean out sand and other solids which settle upon the bottom. The smaller sewers are cleaned largely by means of flush tanks, of which there were 4,369 in the year 1907. The larger sewers are cleaned by apparatus which varies in construction according to the size of the sewer and work to be done, but generally involves the same principle. The flow of sewage is temporarily checked by a movable dam attached to a boat or carriage and so placed as to nearly fill the lower part of the sewer from wall to wall. The sewage which backs up and accumulates behind this dam eventually gathers sufficient force to move it forward, the eddies so caused producing a scour sufficient to dislodge any deposits which may be present. The sand and other heavy solids swept to suitable localities in this way are shoveled into boats or wagons and carted away. Some of the sand is washed and eventually scattered upon the streets to prevent horses from slipping on the wooden block and asphalt pavements.

The normal current in the sewers is 5 ft. per sec., a rate which is very rarely attained under ordinary conditions in other cities. It was intended to be high in order to secure sufficient transporting power for the unusually large proportion of solid matter which it was intended to have the sewers carry.

The sewers are designed to accommodate ¼-in. of rainfall per hour for three hours, after which further quantities are discharged into the Seine by storm overflows. Rainfalls as heavy as ¼-in. in an hour occur eight or ten times a year, but they are of very brief duration.

In maintaining the sewers there are 33 boats provided with cleaning dams such as have been described, and 118 wagons provided with cleaning apparatus operating on the same principle. There are also 9 electric motors, 127 sand wagons and much other apparatus. There are about 1,000 men continually employed in the sewers.

The sewage flows by gravity to the central station at Clichy, small quantities only being raised by pumps to a height sufficient to enable it to reach the largest sewers from particularly low points.

The Sewage Farms.

At Clichy the sewage passes through a grit chamber, coarse screen and fine screen to pumps, which send the sewage to the country. The grit chambers, which collect sand, rags and other solid objects, are continually dredged out and the refuse dumped into canal-boats which are moored close at hand. The fine screens remove matches, corks, shreds of paper, leaves, bits of garbage and other solid matter. The screens are cleaned by moving rakes operated mechanically. It appears that this whole plant has been submerged by the present flood. If this is true it will be impossible to handle any of the sewage which will reach here. The sewage will flow untreated into the Seine.

The pumping plant at Clichy comprises four centrifugal steam pumps of 250 HP. each, four of 130 HP. each, and one electric pump of 220 HP. When the weather is rainy or the land otherwise unsuitable for irrigation, sewage is allowed to flow from the works at Clichy into the Seine. In consequence of this, the river below Clichy is discolored and foul-smelling, while above, the water is as clean and uncontaminated as a naturally somewhat turbid stream can be expected to appear.

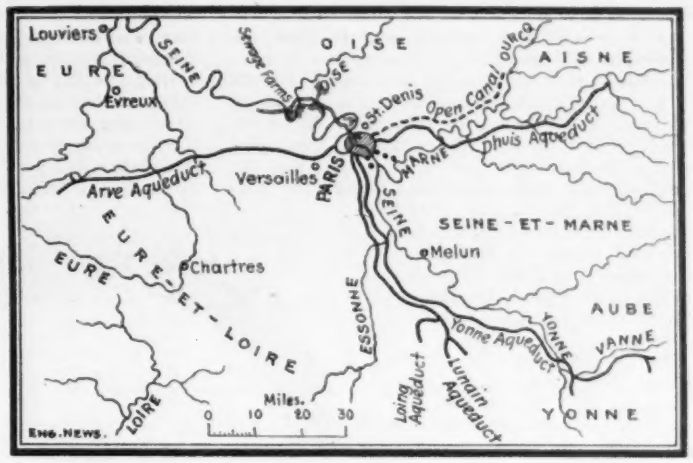


FIG. 9. MAP OF VICINITY OF PARIS, SHOWING SOURCES OF WATER-SUPPLY AND SEWAGE-DISPOSAL FARMS.

Some of the sewage pumped at Clichy flowed to farms now submerged at Gennevilliers, and some to farms at a higher elevation at Achères, Pierrelaye and Triel (see Fig. 9). The quantity sent to Gennevilliers in the year 1906 was 31,000,000 gals. per day. The farms at this point cover 840 acres. The soil contains sand and clay. The crops consist of vegetables, fruit trees, and some meadow land. Here, as at the other sewage farm lands of Paris, the sewage is run into ditches with ridges between containing the crops. The sewage filters through the soil to underdrains placed beneath the ridges. It is said that 8,000,000 to 12,000,000 gals. of sewage can be applied to this land per acre in the course of a year without injury to the crops or impairment to the quality of the water which flows from the underdrains.

The sewage for the other farms is pumped a second time at Colombes. At this station, as at Clichy, there are grit chambers and screens. A surprisingly large quantity of solid matters is removed at these pumping plants, in view of the continual removal of the deposits which occur in the sewers in Paris. During the year 1906 there were 56,309 cu. yds. of solids removed at Clichy and 103,233 cu. yds. taken out at Colombes. During this same year the solids removed from the sewers within the limits of Paris amounted to 42,146 cu. yds. The exact quantity of sewage from which this material was removed is not ascertainable, since an unmeasured quantity was allowed to flow directly to the Seine at Clichy. Reckoned on the basis of the water-supply, 1 cu. yd. was taken from each 350,000 gals.

The quantity of sewage pumped at Colombes in 1906 was 138,000,000 gals. per day. During the same year the total volume of sewage from Paris averaged not far from 218,000,000 gals. per day. A small quantity of sewage is produced in the northern part of Paris which is not carried to Clichy but to an outfall at St. Denis.

There are 18 pumps at Colombes. The sewage is here raised 125 ft. and sent to the farms at

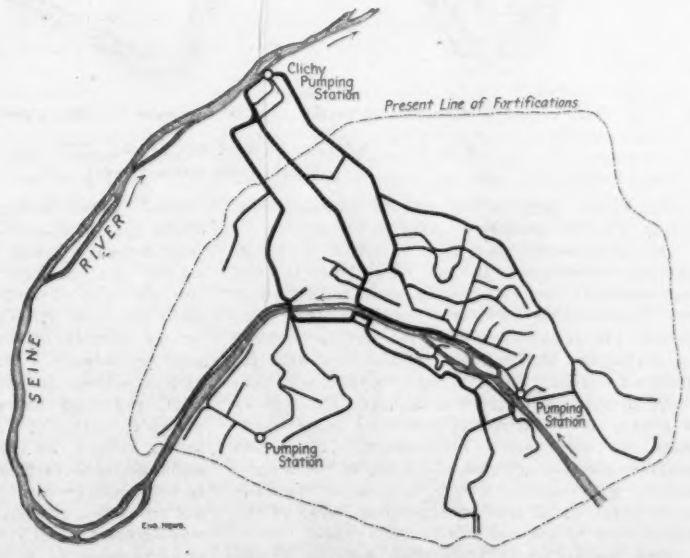


FIG. 10. MAIN COLLECTING SYSTEM FOR THE SEWAGE OF PARIS.

Achères, Pierrelaye and Triel. The sewage for Achères passes again under the Seine, being siphoned under this stream for the third time after leaving Clichy. In 1906 the quantity of sewage sent to Achères was 38,600,000 gals. per 24 hrs. The area of farm lands at this point is 3,500 acres.

A short distance beyond Achères and to the north of it lie the sewage farms of Pierrelaye. There are here 5,400 acres of land. The quantity of sewage sent to this point in 1906 was 46,400,000 gals. per day. It is necessary to raise the sewage here by pumping to a height of 88 ft.

The most distant sewage farms are near Triel, 17 miles from Paris. In 1906 these farms received 29,100,000 gals. of sewage per day. The area of land is 2,400 acres. Before reaching the Triel disposal fields, sometimes termed the Carrieres-Triel farms, this sewage has been pumped twice, has been siphoned under the Seine twice and under the River Oise once. It has twice passed through grit basins and coarse and fine screens.

The average rate at which the sewage was applied to the Paris farms in 1906 was 10,000 gals. per acre per day. The sewage after utilization flows away into the Seine a clean water, having lost practically all of its impurities.

The quantities of sewage produced in Paris are increasing so that the available land will soon be wholly occupied for the disposal of the wastes and some other method of purification will be needed. Practical experiments have been made at Paris into methods of intensively purifying the sewage, such as by the use of sprinkling filters, and it is probable that in course of time the sewage farms will be abandoned for a more modern method of treatment.

The health of the persons who work upon the fields is in no way affected by the sewage. The village of Pierrelaye, containing several thousand inhabitants, is literally surrounded by sewage farms. Some trouble has been produced from flooding cellars, but in spite of this, this village, as is true of others situated near sewage disposal works, bears every appearance of well-being.

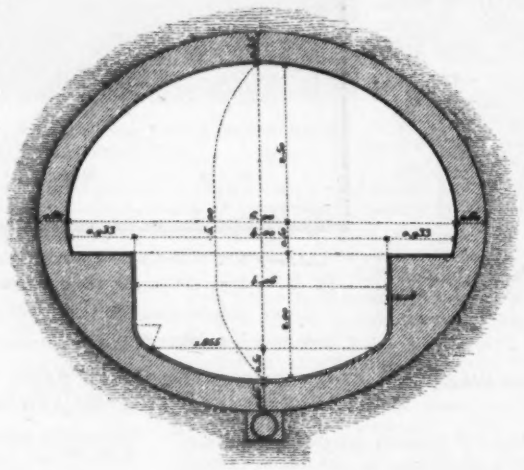
Before leaving the subject of health, it may be well to mention that the laborers who work in the sewers within the city of Paris enjoy excellent health. They suffer no more from typhoid fever and other diseases transmitted by excrementitious poisons than persons employed in other vocations. The air of the sewers is regularly analyzed and reported upon by scientists in the employ of the city, and from their reports and the evidence of the senses the atmosphere appears to be thoroughly satisfactory. The air is damp and slightly musty, but otherwise not disagreeable. The large number of direct openings to the sewers from the streets and the air currents produced by the moving sewage bring about a sufficient amount of ventilation for all purposes.

The Subways or Underground Railways.

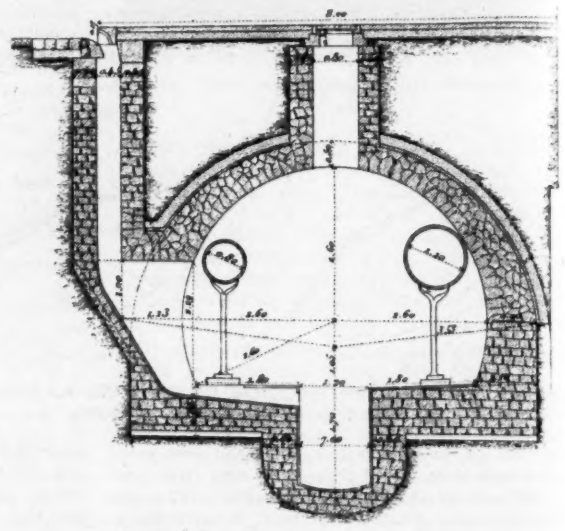
Closely related in point of public interest to the sewers are the underground railways of Paris (Fig. 12). There are two principal systems of subways. One is the original line built by the municipality in accordance with an elaborate plan made as a result of a law passed in 1898. The road is operated by a private corporation called the Compagnie du Chemin de fer Metropolitan de Paris under a thirty-five year contract. The original plan called for eight lines of subway, the total length to be 47.7 miles. In 1907 there were 28 miles of road completed and in operation. All of this was not subterranean; some parts of the line run above ground. The underground parts of this subway traverse the city in many directions, connecting the great railroad stations and the principal centers of business and pleasure with the residence sections. The most important parts of this subway are now flooded and the water has been carried dangerously near the foundations of some of the most important buildings.

The Metropolitan subway of Paris resembles the underground roads of Buda Pest, Berlin and the Rapid Transit Subway of New York. It is distinguished from the London tubes by running close beneath the surface of the streets. The standard section is formed by an elliptical arch having a width of 23.3 ft. and a rise of 6.79 ft., supported by two side walls 9.54 ft. high, finished by circular arcs. The total inside height is 17.6 ft.; the width at rail level 21.6 ft. The standard station has side platforms 246 ft. long and about 13 ft. wide. The stations are reached by stairof any structure, is dependent upon a firm fou dation. A heavy pressure acting outward fr within a railway subway or sewer would p duce a strain not provided for in the design a would probably result in rupture where the ou side pressure working toward the center wou be insufficient to counteract it. Again, a ru of water outside the structure would cause t soil to be washed from beneath, proper suppo would be withdrawn, and rupture might occ from the unsustained weight.

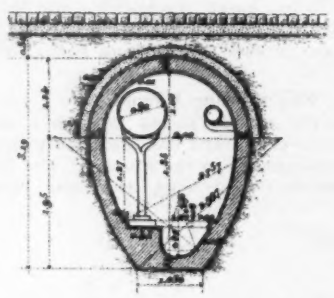
A private enterprise known as the Nord-S Railway has recently been in process of co struction in Paris, the object being to carr passengers by subway across the city in nort and south directions. The distinguished engi neer, Georges Bechmann, dean of the municipa engineers of Paris, has been in charge of thi



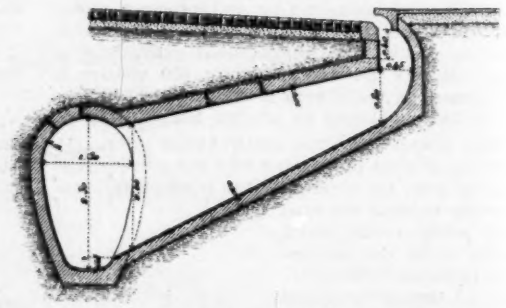
A. Main Collector at Clichy.



B. A Principal Sewer in Center of City.



C. Section under Important Streets.



D. Entrance for Storm Water from Street Surfaces.

FIG. 11. TYPICAL SEWER-SECTIONS, CITY OF PARIS.
(Metric Dimensions Used.)

cases which open to the streets through sidewalks without kiosks or other coverings.

The unpleasant conditions resulting from insufficient ventilation in the New York subway immediately after its opening were duplicated in the Metropolitan of Paris, and for the same reason. Both subways were too tightly enclosed to enable the air to move in and out with requisite freedom. Subways of this type will ventilate themselves if given a chance. The remedy is simple and consists in providing more blowholes to the outer atmosphere. Numerous analyses have been made of the air of the Metropolitan with results which in general resemble those obtained in the investigations made of the atmosphere of the subway in New York.

Press dispatches indicate that portions of the subways and sewers have blown up; that other parts have caved in and that the damage to the city by flood has been greatly increased by the volumes of water which have been transported by the underground structures. There are various ways in which the injuries done can be accounted for. The roofs of the subways, like those of the sewers, were constructed to withstand pressure from without. Their integrity, like that

work. Other subterranean railways exist in Paris besides the electrically-operated roads just mentioned. A trunk line railroad enters the city in the southeasterly quarter and passes along the left bank of the Seine with two principal stations (see Fig. 7). One of the stations is known by its location on the Quai d'Austerlitz. After passing beneath a public square in the vicinity and traversing an extensive wine warehouse district, the road passes beneath the streets for about 2½ miles to a second station known, also by its locality, as the Gare du Quai d'Orsay. A short distance further west, along the left bank, is the underground station, known as the Gare des Invalides, of another road. These three railway stations, with their underground connections, appear to be entirely submerged by the flood.

In the southern part of Paris the Gare Montparnasse is the terminal of the Chemin de fer de l'Ouest. This line runs for somewhat over a mile underground before emerging from the confines of Paris, but it is located in high ground and is not in danger of flooding.

In the southeast quarter of Paris is the underground river known as the Bièvre. This stream

has been confined to a width of about 10 ft. It follows an irregular course and discharges eventually into the Seine.

Danger of Epidemic.

When a great calamity such as the Paris flood, the Galveston disaster or the San Francisco fire occurs, the distressing circumstances of the moment are usually aggravated by fears of pestilence. The fact that pestilences seldom follow floods is either not known or not appreciated. It seems natural for human beings to associate what seems to be a complete disorganization of the municipal machinery, a large part of which in every city has a direct relation to health, with the most terrible consequences. Plagues, pestilences and famines, now largely eliminated from civilized parts of the globe, seem about to show their terrible countenances after great disasters. As a rule the fears of pestilence are not realized. The health of the people of San Francisco was

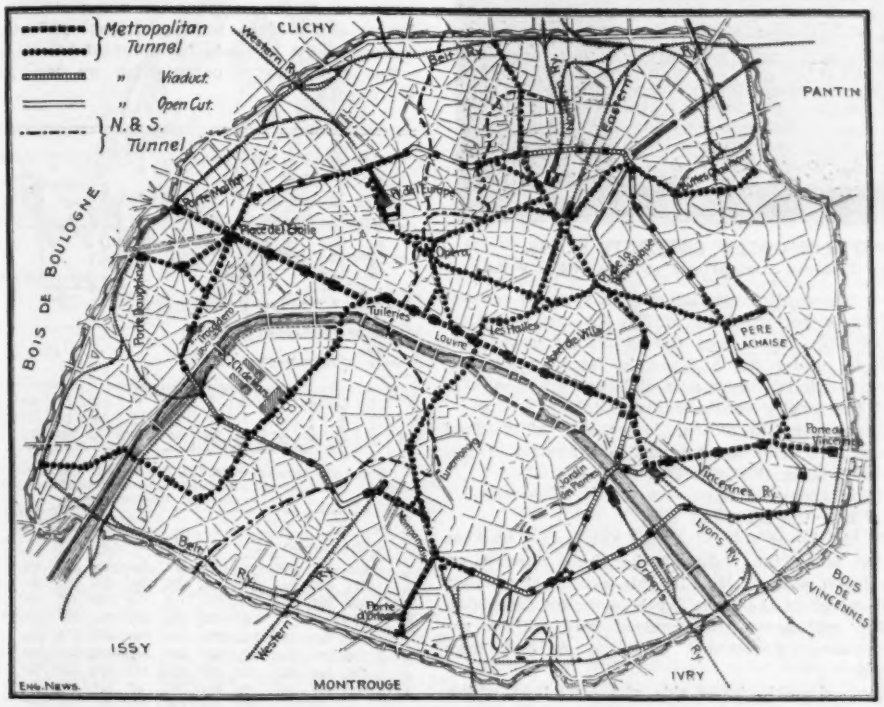


FIG. 12. PASSENGER-SUBWAY SYSTEMS OF PARIS.
(Reprinted from Eng. News of Dec. 6, 1900)

remarkably good after the great calamity. There was no outbreak of epidemic disease at Galveston after the flood of 1899. It is true that in these instances the management of public health questions was in competent hands, but in a score of other instances which might be cited, fears of epidemic have not been realized.

Fear that an epidemic of typhoid fever will follow the Paris flood occupies the minds of many persons. To them it seems that the bursting of the sewers and the disarrangement of the water supplies must lead to terrible consequences.

A greater danger than the bursting of the rivers is the flooding of the cesspools. The flooding of sewers, by enormously diluting the infectious matters present, will reduce the risk of taking them into the human system, but the flooding of cesspools will have no such cleansing and flushing effect. The cesspools will simply fill to the top with relatively concentrated filth and the additional excrement which it seems they will inevitably receive will cause them to overflow.

The extent to which the water-supplies, particularly the drinking water from springs, are interfered with is not known at the present writing. The supplies are from a sufficient number of sources and distributed through a sufficient number of reservoirs at high elevations to make it appear that there will remain a sufficient quantity of serviceable drinking water to satisfy the public requirements. And if the regular distribution of drinking water is interfered with the people of Paris, already well informed upon hygienic subjects, and advised by thoroughly competent authorities, should be able to protect themselves against the chief danger of polluted water by boiling so much of it as they may need for drinking purposes.

The greatest danger from disease seems to lie in the possibility that great numbers of refugees will flock to Paris and add their presence to the already crowded sections of the city. Crowding is dangerous, because it permits infectious matters to be transmitted with uncommon speed and directness from person to person. Experience shows it to be inevitable where many are gathered together that some shall be sick and that others shall be the innocent producers and distributors of the germs of transmissible diseases. Scarlet fever is said to have broken out already in one of the immediate suburbs of Paris, but it is still too soon to know whether a serious outbreak of any disease will occur. If the hospitals become overcrowded, pneumonia, erysipelas, or any of a number of other highly contagious diseases may appear. The French authorities are, however, as able as any to cope with such difficulties and, having at command all the resources which the whole world can bestow, should prevent the occurrence of epidemic disease so far as it is humanly possible to do so. It is to be hoped that they will see in the present an excellent opportunity to initiate a thorough campaign of municipal housecleaning, and that they will lay emphasis upon the preeminent value of simple and time-tried measures of sanitation in place of the elaborate ultra-scientific and inefficacious steps sometimes taken after great calamities.

Having attained its maximum of violence, the Seine may be expected to subside rapidly. How soon the water will disappear from the streets of Paris depends upon how soon the sewers and subways regain their normal working order. Three conditions may contribute to a rapid subsidence of the river. First, cold weather, which is capable of freezing the smaller tributaries and holding back water upon the land so that the volume carried by the river will have a better opportunity to flow away. Second, a return of normal weather conditions, which means a cessation of the precipitation that brought down upon the Seine the excessive quantity of water. Third, the outflow of the river to the sea. It is not impossible that all these conditions will operate together and that the danger stage of the river, which came on and reached its height within about a week, will pass away within as short a period of time. The damage done, of course, cannot be repaired in months.

The business of pumping out the cellars of houses where furnaces, electric apparatus and plumbing fixtures are urgently needed, will be a slow and laborious process, but once the sewers are in condition to carry the water from the streets, the pumping out process may be expected to proceed with characteristic French industry.

Under normal conditions Paris enjoys an excellent reputation for healthfulness as compared with other cities of its class. Its average general death rate for the five years 1900 to 1904 was 18.2 per 1,000 of population. This was smaller than New York (19.4) or Berlin (18.3) and but little higher than London (16.9). As to typhoid fever, Paris stood second among the four greatest cities of the world with a death rate of 12 per 100,000 of population in the five years included between 1901 and 1905. Its rate was lower than that of New York (17.8) or London (14.3), but higher than the phenomenally low rate of Berlin (5).

INVESTIGATIONS OF SWAMP RECLAMATION in Maryland are recommended by the State Conservation Commission, of which Mr. Bernard M. Baker is a member. Particular mention is made of "the great swamp areas adjacent to the Chesapeake Bay." Attention is also called to "the necessity of the acquisition on the part of the state, at an early day, of the deforested areas around the headwaters of the streams affording" the chief water-supplies of the state. The Maryland Conservation Commission consists of eleven members, and in its work during 1908 and 1909 has had the cooperation of the Geological Survey, Boards of Health and Forestry, and other state boards and commissions.

THE FIRST 15-CYCLE SINGLE-PHASE RAILWAY in this country, running from Visalia to Lemon Cove, Tulare County, Cal., has now been in operation two years and a few operating data have recently been announced. The line is 22 miles long and ten miles, between Visalia and Exeter, is a part of the steam road of the Southern Pacific Co., Porterville branch. The line is single-track except for the yards at Visalia, Lemon Cove and Exeter. A single-catenary trolley suspension is employed, with side brackets on poles spaced 120 ft. apart.

From Visalia to Exeter the country is practically level. Between Exeter and Lemon Cove the land is of a rolling nature, but the maximum gradient on the road has been kept down to 0.9% and the curves are of long radius. The worst conditions are met on a combined 10° curve and 0.9% grade.

Power is purchased from the Mt. Whitney Power Co., operating a 60-cycle, three-phase, 33,000-volt power system, primarily for irrigation pumping in the foothill orange district about Exeter, Lindsay, Porterville and Visalia. At Exeter the 60-cycle current is stepped down to 2,200 volts and fed to a rotary-converter substation. From here the power is sent out on the feeder lines at 15 cycles, 11,000 volts. Eight miles each side of Exeter are transformer substations, reducing the 15-cycle, 11-000 volt current to trolley potential, 3,300 volts.

The rolling stock comprises a 47-ton, 500-HP. locomotive; four 40-ton, 300-HP. passenger motor cars; two 28-ton trailer passenger cars. The entire equipment was furnished by the Westinghouse Electric & Manufacturing Co., of Pittsburg.

The capacity of each substation was designed to take care of the electric locomotive fully loaded, or one train of two motor cars and a trailer. In general service, only single motor cars are operated, without trailers, but when crowds are to be handled, or the traffic conditions warrant, three-car trains are run. As an operating test, a six-car train has been successfully operated over the entire system. The maximum regular operating speed is 45 mi. per hr., although a single motor car has developed a speed of 62 mi. per hr. The fast cars of the system run from Visalia to Exeter in 23 minutes, and from Exeter to Lemon Cove in 21 minutes, calling for a schedule speed of 31 mi. per hr.

During a period of 40 days over which readings were taken, the average power consumption of the locomotive was 73.4 watt-hrs. per ton-mile. During 60 days of operation of the motor cars, the actual power consumption at the car was found to be 55.9 watt-hrs. per ton-mile. During 60 days, the average output of the frequency changing substation was 70.25 watt-hrs. per ton-mile, although during another period of 30 days when operating conditions were better, the average station output was 68.6 watt-hrs. per ton-mile.

A Slide-Rule for Reinforced-Concrete Slabs.

It is probable that every engineer constantly engaged in the design of reinforced-concrete members has developed for himself some sort of tables or diagrams whereby the routine labor of his computations may be lightened. Such tables or diagrams must be based on assumptions of unit-stress, distribution of load and strain and variation of reinforcement peculiar to the ideas of that engineer alone, and although the results, in the main, from various methods may be alike, there is undoubtedly so much of the personal equation in the use of these short-cut methods that we have of late refrained from giving much publicity to them. In addition, the great number and variety of schemes has precluded our noting any one of them. However, there has recently come to our attention a new slide rule for the computation and stress determination of reinforced-concrete slabs, which is very compact and, within a limited field, very useful. This device which we describe and illustrate herewith was invented by Prof. Arthur W. French, of Worcester Polytechnic Institute, for his own use, but it proved so valuable to him that he decided to place it on the market.

In the first place it should be said that the rule solves problems under but one assumption of steel unit-stress, concrete unit-stress and modulus of elasticity ratio, so that any one using it must accept those assumptions and no others. It is available only for tensionally reinforced slabs, and can be applied to beams and girders only when they are of moderate size. On the other hand it allows several varieties of reinforcement and a most general distribution of the steel on the lower side of the slab.

The face of the slide is shown in Fig. 1, reduced there somewhat from the full size 4¼ x 9 ins.

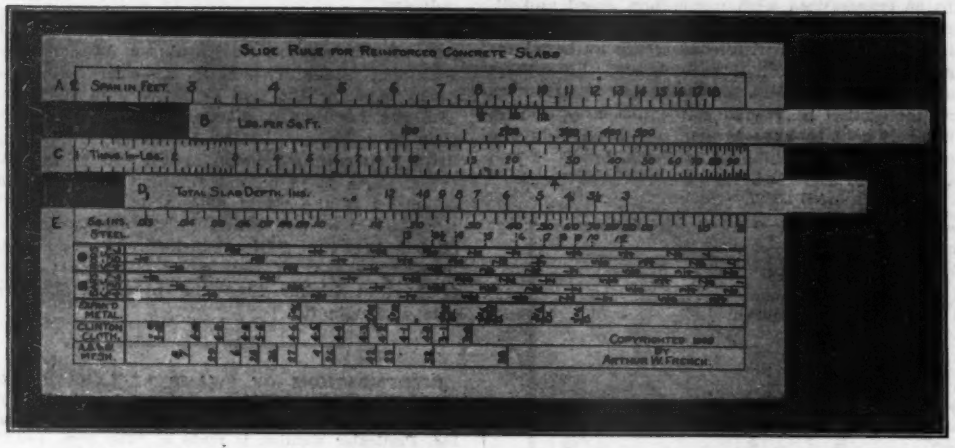

Slide Rule for Reinforced Concrete Slabs
A & C Span in Feet
B Lbs. per Sq. Ft.
C Thous. in Lbs.
D1 Total Slab Depth, Ins.
E Sq. Ins. Steel
Expd'd Metal
Clinton Cloth
Wire Mesh
Copyrighted 1909 by Arthur W. French.

FIG. 1. FACE OF SLIDE RULE FOR COMPUTING REINFORCED CONCRETE SLABS.
(Designed by Prof. Arthur W. French, Worcester Poly technic Institute. Actual size of Rule, 4¼ x 9 ins.)

the compression in concrete governs, below that amount the tension in the steel. The slide rule is only a mechanical method of solving the moment equations shown in Fig. 8, using one side of slide D for the steel moment equation and the other side when the proportion of steel requires the use of the concrete moment. The best method of explaining the operation of the rule will probably be to go through some specific examples. All slabs are assumed to be 12 ins. wide.

EXAMPLE I.—(Rule in position shown in Fig. 1). To select proper depth and reinforcement for a non-continuous slab of 8 ft. span, to support safely a uniform load of 275 lbs. per sq. ft.

Set slide *B* so that the ⅛ on its upper side will be under the 8 (span in feet) on slide *A*. (For partially continuous slab use fraction 1/10 and for wholly continuous use 1/12.)

Under the 275 on the lower side of *B* (load per sq. ft.) read the moment in thousand in.-lbs. on slide *C*, in this case 26,400 in.-lbs.

Bring arrow on upper side of D_1 under the 275 of *B* and the 26,400 of *C*.

On the lower side of *E* find the lowest number which is to the right of the same number on the lower side of D_1. In this case that number is 6, which is the least depth in inches for a slab which will carry the required load with a reinforcement percentage equal to or less than 0.68%.

Above 6 on the lower side of *E* read 0.40, which is the area of steel required. Below 6 on the lower side of *E* may be read the various ways of making up that amount of steel, e. g., ⅝-in. rounds spaced 6 ins. c. to c., ½-in. rounds spaced 5 ins. c. to c., 7/16-in. rounds spaced 4 ins. c. to c.; ½-in. square rods 6 ins. c. to c., 7/16-in. squares 5 ins. c. to c., ⅜-in. squares 4 ins. c. to c.; and 3-in. No. 6, extra strength expanded metal. For this particular case the Clinton wire cloth and American Steel and Wire Co.'s mesh are not given in sufficient strength.

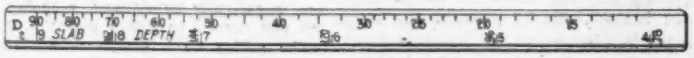


FIG. 2. SLIDE D_2 ON THE FRENCH SLIDE RULE (REVERSE OF D_1 SHOWN IN FIG. 1).

It will be seen that there are five main horizontal divisions, lettered from *A* to *E*, which are used to determine the dimensions of the slab, and below them are nine smaller horizontal divisions, giving the number and sizes of different kinds of reinforcement necessary to make up the required area as determined in the upper part of the rule. Of the five lettered divisions, *A*, *C* and *E* are fixed and *B* and *D* are slides. *B* is scaled on one side only, but *D* has scales on both sides lettered, respectively, D_1 and D_2.

The theory of the rule is based on the commonly accepted straight-line theory for reinforced-concrete beams. This theory is algebraically expressed in the upper part of Fig. 3 (which is a reproduction of the back face of the rule). With the assumptions of 600 lbs. per sq. in. compression in the concrete and 16,000 lbs. per sq. in. tension in the steel, the maximum safe stresses in concrete and steel are reached at a steel percentage of 0.68%. Above this amount of steel if it is desired to use a certain size of round or square rod, its spacing to make the given area read from the upper side of *E* may be taken from the tables on the back of the rule, shown in Fig. 3. For instance, in the example, if ⅝-in. rounds are to be used they must be spaced 12 ins. c. to c., the table showing 0.442 sq. ins. to take care of the 0.40 ins. read off *E*, as noted above.

The amount of steel necessary for a slab thicker than 6 ins. may be read directly from the lower side of D_1, thus, a 7-in. slab wire requires 0.31 sq. ins. of steel, an 8-in. slab, 0.27 sq. ins, etc.

If it is desired to use a depth less than 6 ins., that is a depth which will require more than the 0.68% of reinforcement, the concrete moment governs and the reverse side of slide *D* is used, that is, D_2, shown by itself in Fig. 2. To use this, set under the bending moment on *C* the same figure on D_2 and read then the correct amount of steel on scale *E* under the slab depth desired on the lower side of D_2. The vertically reading figures alongside of each slab depth on D_2 are the respective areas of steel which, for each depth, equal 2% of the concrete area, a figure above which it is not usually desirable to design.

EXAMPLE II.—(Slide-rule in cuts not set for this example.)

What live load per sq. ft. will a 6-in. slab, reinforced with ½-in. round rods spaced 6 ins. c. to c., carry on a span of 8 ft. if the slab be one of a series of continuous spans?

Set 6 of D_1 over the mark designating ½-in. rounds on 6-in. spacing below *E*.

Place 1/10 on upper side of *B* under 8 of *A*.

Over arrow on D_1, read 362 on *B*.

Subtracting weight of slab (½ cu. ft. concrete = 75 lbs.) from 362 gives load capacity as 290 lbs. per sq. ft.

The scales are all computed for a uniform slab width of 12 ins. so that, in using the rule for beams and girders, a proportionate reduction or increase must be made for different beam widths.

The slide-rule is copyrighted by Mr. Arthur W. French.

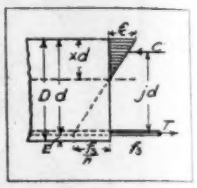
f_c = max. stress in concrete = 600 lbs. per sq. in.
f_s = max. stress in steel = 16000 lbs. per sq. in.

$n = \frac{E_s}{E_c} = 15$. $p = \frac{\text{steel area}}{\text{concrete area}}$

$j = 1 - \frac{x}{3}$. $x = \sqrt{2np + (np)^2} - np$

$M = 16000\ pjbd^2$ when $p \leq .0068$

$M = \frac{600}{2}\ xjbd^2$ when $p > .0068$



D	3	3½	4	5	6	7	8	9	10	12	inches
E	¾	¾	¾	1	1	1	1½	1½	1½	1½	inches
Wt.	36	42	48	60	72	84	96	108	120	144	lbs. per □ ft.

SECTIONAL AREA OF STEEL (SQ. IN.) PER FT. WIDTH OF SLAB.

SIZE.	12" ○	12" □	7" ○	7" □	6" ○	6" □	5" ○	5" □	4" ○	4" □	3" ○	3" □
¼	.012	.015	.021	.026	.025	.031	.029	.037	.037	.047	.049	.062
5/16	.027	.035	.047	.060	.055	.070	.066	.084	.083	.105	.110	.141
⅜	.049	.062	.084	.107	.098	.125	.118	.150	.147	.187	.196	.250
7/16	.077	.098	.131	.167	.153	.195	.184	.234	.230	.293	.307	.391
½	.110	.141	.189	.241	.221	.281	.265	.337	.331	.422	.441	.562
9/16	.150	.191	.258	.328	.300	.383	.361	.459	.451	.574	.601	.765
⅝	.196	.250	.336	.428	.392	.500	.471	.600	.589	.750	.785	1.000
¾	.307	.391	.525	.670	.614	.781	.736	.937	.920	1.172	1.227	1.562
⅞	.442	.562	.758	.964	.884	1.125	1.061	1.350	1.325	1.687	1.767	2.250
1	.601	.765	1.031	1.312	1.202	1.531	1.442	1.837	1.804	2.298	2.405	3.062
1	.785	1.000	1.346	1.714	1.571	2.000	1.885	2.400	2.356	3.000	3.142	4.000
1¼	.994	1.265	1.704	2.169	1.988	2.531	2.386	3.036	2.982	3.797	3.976	5.062
1¼	1.227	1.562	2.103	2.679	2.454	3.125	2.945	3.750	3.682	4.687	4.909	6.250

WEIGHT OF STEEL (LBS.) PER SQ. FT. OF SLAB.

SIZE.	12" ○	12" □	7" ○	7" □	6" ○	6" □	5" ○	5" □	4" ○	4" □	3" ○	3" □
¼	.042	.053	.072	.091	.084	.106	.101	.127	.126	.159	.168	.212
5/16	.094	.119	.161	.204	.188	.238	.226	.286	.282	.357	.376	.476
⅜	.167	.212	.286	.363	.334	.424	.401	.509	.501	.636	.668	.848
7/16	.261	.333	.447	.571	.522	.666	.626	.799	.783	.999	1.044	1.332
½	.375	.478	.643	.819	.750	.956	.900	1.147	1.125	1.434	1.500	1.912
9/16	.511	.651	.876	1.116	1.022	1.302	1.226	1.562	1.533	1.953	2.044	2.604
⅝	.667	.850	1.143	1.455	1.334	1.700	1.601	2.042	2.001	2.550	2.668	3.400
¾	1.043	1.328	1.789	2.276	2.086	2.656	2.503	3.187	3.129	3.984	4.172	5.312
⅞	1.502	1.913	2.575	3.279	3.004	3.826	3.605	4.591	4.506	5.739	6.008	7.652
1	2.044	2.603	3.504	4.462	4.088	5.206	4.906	6.247	6.132	7.809	8 176	10.412
1	2.670	3 400	4.577	5.829	5.340	6.800	6.408	8.160	8.010	10 200	10.680	13.600
1¼	3.379	4.303	5.793	7.376	6 758	8,606	8.109	10.327	10.137	12 909	13.516	17.212
1¼	4.173	5.312	7-154	9.106	8 346	10.624	10.015	12.749	12.519	15.936	16.692	21.248

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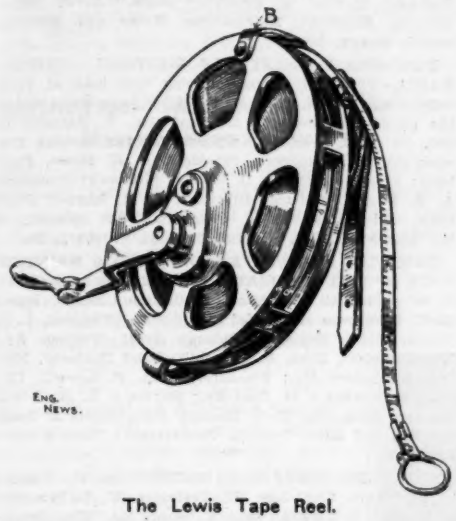
Fig. 3. Back of the Reinforced Concrete Slab Slide Rule.

THE GOLD PRODUCTION IN THE UNITED STATES for the year 1909, according to the preliminary estimate issued by the Director of the Mint, had a total value of $99,232,200. This shows an increase of $4,672,200 over the 1908 production. The production in Nevada showed an increase in value of $3,219,000; that of California increased $1,941,600 in value and the increase for Alaska was $1,088,800. The largest decrease of production for any one state ($392,300) occurred in South Dakota.

A New and Improved Tape Reel.

The tape reel shown in the accompanying view has been devised and put on the market by Mr. Myron H. Lewis, Assistant Engineer, Topographical Bureau, Borough of Queens, New York City. In general appearance it is somewhat similar to the skeleton reels now on the market, but it has at least two innovations, which, in theory and so far in practice, have proved very valuable. These two novel details are a multiplying winding gear and a brake attachment for holding the tape when measuring without bending it. As now manufactured, it is 5⅛-in. in outside diameter and large enough for the standard 100-ft., ¼-in. to 3/16-in. tape. All wearing parts, including the gears, are turned out of solid steel and the bearings are reinforced by brass bushings to prevent wear. The frame is



The Lewis Tape Reel.

of a hard and dense aluminum alloy of a specific gravity of 3.2. Without the tape, the reel weighs about 10 ounces.

The old leather-covered box tape reel had a number of defects, among which may be mentioned the large wearing surface of the axle against the case, the tendency to clog with grit, the very short non-geared handle which makes winding tiresome and slow work and the lack of any device to hold the reel end of the tape unless the whole length is unreeled. The first two of these faults are remedied by the skeleton reels heretofore manufactured, but the last two are novelties of the "Lewis" reel. The location of the gear is shown on the drawing; its multiplication is such that a 100-ft. tape can be reeled up in about 12 seconds. The brake is also shown on the drawing, marked "B." It consists of a flat brass plate pinned to each side of the frame near its perimeter and movable so as to permit its being pressed flat on the tape as it passes between it and a steel plate which is riveted between the inner faces of the frame immediately below the brake. The reel is held so that the hand passes under the adjustable leather strap handle and, with the thumb resting on the brake, a slight pressure will prevent further unwinding, thus obviating the usual necessary grips which bend and tend to kink the tape.

Notes from Engineering Schools.

STEVENS INSTITUTE.—The ninth annual alumni dinner will be held at the Hotel Astor, New York City, on the evening of Feb. 12. Among the speakers will be Dr. Alex. C. Humphreys, President of the institute; Dr. H. S. Pritchett, of the Carnegie Foundation; and Col. G. B. M. Harvey, of "Harper's Weekly."

FOREST FIRE OUTLOOK STATIONS equipped with telescope and telephone are recommended by State Forester Rane, of Massachusetts, in his report to the Legislature of that state. It appears that this method of detecting and reporting fires has already been tried in a few towns in Massachusetts, as also in Maine and elsewhere. The use of these stations would be confined principally to dry weather.

THE ST. PAUL MINE AT CHERRY, ILL., was unsealed Feb. 1 for the resumption of the work of recovering the bodies of men entombed by the fire of Nov. 13, 1909. It is estimated that there are still about 160 bodies in the mine. As soon as the mine was unsealed, three men with oxygen helmets descended to the lowest level, 350 ft. below the surface, and obtained samples of the mine atmosphere, which showed it would be impossible for unhelmeted men to descend to that level.

A COAL MINE EXPLOSION NEAR DRAKESBORO, Ky., Feb. 1, took place when about 100 men were at work in the mine. All but about 30 of the miners reached the surface in safety. Although there was no fire following the explosion and the mine fans were not disabled, it was not possible to begin rescue work until six hours after the accident on account of the accumulation of gases in the entry where the explosion occurred. This entry was 170 ft. below the surface and the explosion originated about 700 ft. from the main shaft.

A COAL MINE EXPLOSION Jan. 31 at Primero, Colo., in the mine of the Colorado Fuel & Iron Co. entombed about 100 men. Three men were killed near the mouth of the shaft and the bodies of five others were brought to the surface by a rescue party. The fans were disabled by the explosions and it was impossible to enter the mine until three hours afterward, when they had been repaired. The first rescue party entered successfully by the air shaft, but the main shaft was blocked by caving. Frantic efforts were being made, at last reports, to clear the blocked shaft. A party equipped with oxygen helmets entered the mine workings by way of an air shaft and at 10 o'clock on the night of the accident 15 bodies had been recovered. One man was found alive in the mine at about 2 a. m., Feb. 1. By evening of the same day a total of 40 bodies had been recovered.

A BRITISH EXPRESS TRAIN WAS DERAILED Jan. 29 at Stoat's Nest station, near London, on the London & Brighton Ry. Eight persons were killed and 30 others injured. Two third-class cars and a Pullman coach were derailed and overturned, and the third-class cars were demolished.

THREE RAILWAY ACCIDENTS, in each of which four persons were killed, occurred on Jan. 27.

In the vicinity of Rome, Italy, a train was wrecked at a washout caused by the floods, and some of the cars were submerged. Four emigrants, reported to be on their way to America, were killed.

Two miles north of Titusville, Pa., on the Pennsylvania R. R., one of the locomotives of a long freight train was derailed and four of the six men in its cab were killed. The train had three locomotives, one in front, one at about the middle of its length and the third at the rear. The forward locomotive was the one derailed and the other two continued to shove the train along until the derailed engine was overturned.

On the Carolina, Clinchfield & Ohio R. R., 16 miles southwest of St. Paul, Va., a work train was backed into a boulder which had fallen on the track at a sharp curve. Four laborers were killed and 16 others were injured.

THE RAILWAY ACCIDENT AT CROTON, N. Y., Dec. 31, on the New York Central & Hudson River R. R., in which a fast freight train telescoped the rear car of the Montreal express, has been attributed by the coroner of Westchester Co. to culpable negligence on the part of the engineer of the freight.

The Montreal express, southbound, had been stopped, it will be remembered, by a train in the block ahead and at the time of the accident was a few feet past signal 19 south of the Croton station. Signal 19 was set at "stop" and the signal at the north end of the same block should have been at "caution," but the freight engineer was supported by his fireman in the statement that the distance signal was at "clear" when he passed it. It was ascertained by the coroner, however, that signal 19 was easily visible on a clear day (such as that of the accident) from as far north as the overhead steel bridge some 2,200 ft. north of where the accident took place. The speed of the freight train was found to have been between 30 and 35 mi. per hr. and it was demonstrated by an actual test of a similar train with the same number of cars that it could be stopped by the air-brakes at this speed within 1,018 ft. The engineer of the freight was held on the charge of manslaughter in the second degree to await the action of the Grand Jury at White Plains, N. Y. The fireman was excused on the ground that all his attention just before the wreck was required for his duties in connection with the taking of water.

The coroner's decision criticises the new, automatic block-signal system and rules for train operation which make it possible for a train to stop with only one "stop" signal between it and following trains and that one signal only a few feet behind it. It is probable that this question will be further investigated by the New York Public Service Commission.

CLEAR LAKE DAM, forming an essential part of the Klamath Irrigation Project (Oregon-California), has been practically completed by the U. S. Reclamation Service. This structure is located on Lost River at the outlet of Clear Lake, California. The dam is of combination earth and rock-fill type, with concrete outlet works and spillway. It has a top length of 940 ft. and a maximum height of 33 ft. It forms a reservoir with a surface area of about 25,000 acres and a capacity of 1,089,000,000 cu. ft. Construction on the dam proper was begun in June, 1909. It is stated that a large part of the 200,000 acres of land to be irrigated under this project is now covered with navigable lakes from which water is to be drawn off.

THE TIMBER PRESERVATION work of 1909 is summarized in the following table, rearranged from a statement presented at the annual meeting of the Wood Preservers' Association in Chicago, Jan. 18. It is considered that the estimate is 10% to 15% too low, owing to the failure of several companies to make returns:

(1) Creosote:		
	Piling	8,960,400 lin. ft.
	Lumber	72,800,600 bd. ft.
	Bridge timber	16,230,700 bd. ft.
	Ties	9,620,420 No.
	Switch ties	1,304,840 cu. ft.
	Paving blocks	1,260,020 cu. ft.
	Cross arms	480,640 cu. ft.
(2) Zinc-chloride:		
	Lumber	1,150,800 bd. ft.
	Bridge timber	840,070 bd. ft.
	Ties	8,640,230 No.
	Switch ties	570,600 cu. ft.
(3) Zinc-oil:		
	Piling	630,800 lin. ft.
	Lumber	430,300 bd. ft.
	Ties	3,260,530 No.
	Switch ties	95,700 cu. ft.
Summary:		
	Piling	9,951,200 lin. ft.
	Lumber	74,381,700 bd. ft.
	Bridge timber	17,070,770 bd. ft.
	Ties	21,521,180 No.
	Switch ties	1,971,140 cu. ft.
	Paving blocks	1,260,020 cu. ft.
	Cross arms	480,640 cu. ft.

RATPROOFING OF BUILDINGS is carefully provided for in the new building ordinance of San Francisco. The provisions to this end embrace the following details:

Ratproofing Basements.—Foundation walls must be of concrete, brick or stone in cement mortar, or equivalent construction; must extend at least one foot above ground; must be at least 8 ins. thick at top; and must have any necessary openings made ratproof with metal screens. The floor area under all buildings must be covered with concrete 1½ ins. thick, except on rock surface.

These provisions apply primarily to the waterfront district. In other parts of the city it is permissible, for buildings less than 800 ft. ground area, to elevate them 18 ins. above ground, with the space below exposed on three sides.

Factories of Food Articles.—Floors of fish markets, bakery shops, sausage factories, candy factories and all places where foodstuffs are prepared for sale must be of fireproof material covered with cement or asphalt, or if of wood must be covered with waterproof material and either 2 ins. concrete or 1 in. asphalt mastic; all to be carried up the walls 8 ins.

Stores Selling Food Supplies.—Meat markets, butter shops, vegetable stores, delicatessen stores, restaurants and bakery stores must have floors of two layers of 1-in. board between which is galvanized iron cloth of 20 gage, ½-in. mesh. This cloth must extend 8 ins. up the walls.

Stables.—Stables must have floors of concrete at least 3 ins. thick covered with ¼-in. of asphalt or cement, and the walls must be of concrete or brick 8 ins. thick up to at least one foot above ground. Manure receptacles must be lined with metal and must be vented by a 12-in. flue to the roof. All feed except hay must be kept in a metal-lined bin or room built ratproof.

These provisions apply to new buildings, or old buildings applied to the respective uses after the passage of the ordinance.

Personals.

Mr. Robert Hawzhurst, Jr., M. Am. Soc. C. E., has opened offices as a consulting engineer at 62 London Wall, London, E. C.

Mr. H. P. Henderson, M. Am. Inst. M. E., has resigned his position as Superintendent of the Goldfield Consolidated Mines Co., Goldfield, Nev.

Mr. W. C. Calvert has resigned his position as an assistant engineer with the Oregon Short Line R. R. to engage in private practice as a civil engineer at Burley, Idaho.

Mr. C. H. Beatty has resigned his position as General Superintendent of the Salt Lake & Ogden Ry. Mr. E. H. Hodson, Mr. Beatty's assistant, has been made Acting General Superintendent.

Mr. J. W. Robins, Vice-President and General Superintendent of the Chicago, Rock Island & Gulf Ry., has resigned that position to become President of the Trinity & Brazos Valley Ry., succeeding Mr. R. H. Baker.

Mr. B. M. Laughead has been appointed Locating Engineer of the Buckhannon & Northern R. R., with

headquarters at Morgantown, West Va. The Buckhannon & Northern extends from the Pennsylvania-West Virginia state line up the Monongahela River to Rivesville, West Va.

Mr. R. K. Stockwell has resigned the position of Smelter Engineer with the Steptoe Valley Smelting & Mining Co. and is now Construction Engineer for the United States Smelting, Refining & Mining Co. For the present, he is in charge of work for that company at Eureka, Utah.

Mr. Charles R. Vannemann, Assoc. M. Am. Soc. C. E., has been appointed by the New York Public Service Commission to be Steam Railroad Inspector, succeeding Mr. Jefferson D. Shults, resigned. The appointment is to take effect March 1. Mr. Vanneman was formerly Engineer Examiner in the New York State Civil Service Commission.

Mr. Louis L. Tribus, M. Am. Soc. C. E., Consulting Engineer and Commissioner of Public Works, Borough of Richmond, New York City, and member of the firm of Tribus & Massa, civil and hydraulic engineers, 86 Warren St., New York City, sailed Feb. 2 for an extended trip in Europe and the Orient for rest and to investigate various features of municipal engineering. A complimentary banquet was tendered to Mr. Tribus Jan. 29 at Lazzari's Caprera Hotel, Rosebank, Staten Island, by the heads of the several bureaus and the departmental officials of Richmond Borough.

Mr. B. A. Wood has been appointed Chief Engineer of the Mobile & Ohio R. R. with headquarters at Mobile, Ala. Mr. A. H. Nicholls has been appointed Division Engineer at Meridian, Miss. Mr. E. G. Buck has been appointed Division Engineer at Murphysboro, Ill. Mr. Wood was formerly Resident Engineer of the Mobile & Ohio at Mobile, Ala., and Mr. Nicholls and Mr. Buck were his assistants.

Mr. Edward B. Richardson and Mr. Richard K. Hale, Jun. Am. Soc. C. E., have formed a partnership as consulting engineers under the firm name of Richardson & Hale with offices at 83 Water St., Boston, Mass. Mr. Richardson was formerly Assistant Engineer with the firm of Hollis French & Allen Hubbard, and Mr. Hale was Assistant Engineer with Mr. Robert Spurr Weston and the firm of Metcalf & Eddy, of Boston, Mass.

Mr. Lewis E. Ashbaugh, M. Am. Soc. C. E., formerly Office Engineer of the Central Colorado Power Co., at Denver, Colo., has been appointed by the Los Angeles, Cal., highway commission to be Assistant Chief Engineer of the county highway project at a salary of $200 a month. Reports state that Mr. Ashbaugh, in his new position, will have charge of the preparation of plans and of other office engineering work on the new highway system.

Brig.-Gen. John G. D. Knight, Corps of Engineers, U. S. Army, was retired for age Jan. 24, and was succeeded by Lieut.-Col. H. M. Chittenden, who was immediately retired for disability resulting from incident of service. As a result of these changes, the following promotions in the Engineer Corps are announced: Maj. Henry C. Newcomer has been made a lieutenant-colonel; Capt. Wm. D. Connor has been made a major First Lieut. Robt. R. Ralston has been made a captain, and Second Lieut. E. D. Ardery has been advanced to the rank of first lieutenant.

Mr. Wm. J. Tripp, General Superintendent of the Boston & Albany R. R., has been made General Superintendent of the eastern district of the New York Central & Hudson River R. R. Mr. James L. Truden, Superintendent of the Albany division of the Boston & Albany R. R., has been promoted to succeed Mr. Tripp as General Superintendent. Mr. Chas. F. Smith, formerly General Superintendent of the New York Central's eastern district, has been made General Superintendent of passenger transportation of both the New York Central and the Boston & Albany.

Mr. A. W. Campbell, M. Can. Soc. C. E., Deputy Minister of Public Works of the Province of Ontario, has been appointed Deputy Minister of Railways and Canals of Ottawa, Ont., to succeed Mr. M. J. Butler, M. Can. Soc. C. E., whose resignation was noted in our issue of Jan. 20. Mr. Campbell's salary is to be $5,000. He will assume office Feb. 5, but Mr. Butler will continue his services in an advisory capacity for a few days after that date. The position of chief engineer of the department of railways and canals, which was also held by Mr. Butler has not yet been filled.

Obituary.

Charles B. Parsons, M. Am. Inst. M. E., a pioneer in the lead mining industry of southeastern Missouri, died Jan. 28 at his home in Riverside, Mo. Mr. Parsons was born in Benson, Rutland Co., Vt., in 1836 and was educated in the public schools of Michigan. For a time after the close of the Civil War, during which he served in the Fourth Michigan Volunteer Infantry, he was engaged in mining in Massachusetts. In May, 1867 he went to Borne Terre, Mo., to become Superintendent of the St. Joe Lead Co., with which he was still associated at the time of his death as Resident Director, although h's advanced age had prevented his active participation in its management for several years.

James Keys, Assistant Engineer in charge of the bridge department of the Union Pacific R. R., died Dec. 27 at Excelsior Springs, Mo. Mr. Keys was educated at Lehigh University and after leaving college was first employed by the American Bridge Co. at Pencoyd, Pa. His next position was in St. Paul, Minn., in the bridge department of the Great Northern Ry. He entered the service of the Union Pacific in March, 1901, as a designer in the bridge department and was subsequently put in charge of the department with the title of Assistant Engineer. Mr. Keys was a member of the American Railway Engineering and Maintenance of Way Association, and at the time of his death was Vice-Chairman of the association's committee on wooden bridges and trestles.

William Buchanan, former Superintendent of Motive Power of the New York Central & Hudson River R. R., died Jan. 20 at his home in South Norwalk, Conn. Mr. Buchanan was born in 1830 in Scotland, but came to the United States when a boy. He entered railway service in 1847 as an apprentice in the shops of the Albany & Schenectady R. R., where he remained about two years. In 1849 he entered the employ of the Hudson River R. R. as a machinist, and later served as a locomotive engineer and as a shop foreman with the same road. He was made Master Mechanic of the Southern Division of the Hudson River R. R. in 1853 and became Master Mechanic of the entire line and of the Troy & Greenwich R. R. in 1859, retaining this position 21 years. After a year's service as Superintendent of Motive Power of the Hudson River & Harlem division of the New York Central, he was made Superintendent of Motive Power of the entire New York Central & Hudson River R. R. and its allied lines. He held this position from April, 1881 until his retirement in May, 1899.

Rudolph von Wieser, a civil engineer, died Jan. 22 at Mexico City, Mexico, aged 66 years. Mr. Wieser was born in Austria and was a graduate of the Royal Artillery School at Vienna. After brief service in the Austrian army, he came to the United States in 1864 and enlisted with Company M, Fourth Missouri Cavalry. He served on the staff of Gen. Grierson during a raid through the State of Mississippi. After the close of the Civil War he took part as an engineer in the construction of a railway from Vera Cruz to the City of Mexico. He later returned to the United States and became an assistant to Capt. James B. Eads. In this capacity he had charge of the masonry construction for the Eads Bridge across the Mississippi River at St. Louis, Mo. His next position was that of Chief Masonry Inspector of the Cincinnati Southern Ry., then under construction. The excellency of the masonry of that railway was well known by engineers of 30 years ago and favorable notices were published at that period in various European journals citing it as a departure from the usual American practice. When construction was well under way, the office of Chief Masonry Inspector was abolished and Mr. Wieser was made Division Engineer of division "C," which included the Kentucky River Bridge designed by C. Shaler Smith and notable as the first practical application of the cantilever in construction on a large scale.

The last 30 years of his life were spent in Mexico and in Central and South America. He was Consulting Hydraulic Engineer to Dom Pedro, Emperor of Brazil, and designed important harbor improvements in that country. He spent some years in Nicaragua in the interests of the Nicaragua Canal Co. and became a warm personal friend of President Zelaya. Mr. Wieser was at one time a contractor in Mexico. About a year ago he completed the plans for the terminals for the railways entering the port of Vera Cruz, Mex. This was his last engineering work.

Engineering Societies.

COMING MEETINGS.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 8. Annual meeting at New Haven, Conn. Secy., J. Frederick Jackson, Box 1304, New Haven, Conn.

OHIO ENGINEERING SOCIETY.
Feb. 8-10. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 10. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, E. Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 16-17. Annual convention at Cedar Rapids, Iowa. Secy., A. H. Ford, Iowa City, Iowa.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Feb. 18-21. Annual convention at Chicago, Ill. Chairman, notification committee, O. U. Miracle, Minneapolis, Minn.

NATIONAL ASSOCIATION OF CEMENT USERS.
Feb. 21-26. Annual convention at Chicago, Ill. Pres., Richard L. Humphrey, Harrison Bldg., Philadelphia, Pa.

ENGINEERING SOCIETY OF WISCONSIN.
Feb. 23-25. Annual meeting at Milwaukee, Wis. Secy., W. G. Kirchoffer, 31 Vroman Bldg., Madison, Wis.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Feb. 24-26. Annual meeting at Chicago, Ill. Secy., D. J. Hauer, 721 Park Row Bldg., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
March 1-5. Annual meeting at Pittsburg, Pa. Secy., R. W. Raymond, 29 West 39th St., New York City.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 15-17. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—The annual meeting will be held at the Coliseum, Chicago, Ill., May 23-28. Mr. T. C. Martin, Secretary, announces that the membership has been increased by 1,200 in the last three months.

NEW ENGLAND WATER WORKS ASSOCIATION.—At the monthly meeting to be held in Boston, Mass., Feb. 9, two papers will be presented, as follows: "Depreciation" (as related to water-works accounts), L. G. Powers, Chief Statistician, Department of Commerce and Labor, Bureau of the Census, Washington, D. C.; "The Purchase of Coal on Efficiency Basis," A. O. Doane, Division Engineer, Metropolitan Water and Sewerage Board, Boston, Mass.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—The 30th annual meeting was held at Pittsburg, Pa., Jan. 18. Mr. E. K. Morse, who succeeded to the presidency upon the death of Geo. T. Barnsley on Oct. 23, 1909, presided. Officers for the ensuing year were elected as follows: President, E. K. Morse, Pittsburg; Vice-President, J. O. Handy, Pittsburg; Treasurer, A. E. Frost, Pittsburg; Directors, A. R. Rayner, Pittsburg, and Willis Whited, Pittsburg. The secretary is Mr. Elmer K. Hiles, 803 Fulton Bldg., Pittsburg, Pa.

AMERICAN RAILWAY ENGINEERING & MAINTENANCE OF WAY ASSOCIATION.—Nominations for officers to be elected at the annual meeting in Chicago, March 15-17, have been announced as follows: President, L. C. Fritch, Chief Engineer, Chicago Great Western Ry.; Vice-President, Chas. S. Churchill, Chief Engineer, Norfolk & Western Ry.; Treasurer, Chas. F. Loweth, Chicago, Milwaukee & St. Paul Ry.; Secretary, E. H. Fritch, Chicago; Directors, F. S. Stevens, Philadelphia & Reading Ry., and Robt. Trimble, Pennsylvania Lines West of Pittsburg.

NEW YORK ELECTRICAL SOCIETY.—At the meeting in New York City, Jan. 27, Professor W. S. Franklin, of Lehigh University, gave a lecture on "The Practical Applications of the Gyrostat." Professor Franklin discussed the kinematical diagram for the gyroscope, the action of the fly-wheels of automobile engines, Schlick's device for steadying ships at sea, the Brennan monorail car and the gyrostatic action of the boomerang. Mr. Richard Scherl and Mr. Paul Froelich, inventors of the Scherl monorail car described in our issue of Jan. 27 were present at the meeting and gave a description of their invention.

TREASURY CONSTRUCTION SOCIETY.—The inaugural meeting was held at Chicago, Ill., Jan. 22. The membership consists of the inspectors and superintendents of construction under the control of the Supervising Architect's office, U. S. Treasury Department. There are at present about 120 such superintendents and inspectors in the field and about as many chiefs of divisions, designers, etc., in the Washington office who are also eligible to membership. It is the purpose of the society to hold annual meetings for the discussion of subjects pertaining to the construction of Government buildings.

Officers for the first year have been elected as follows: President, Thomas Appleton, Alton, Ill.; First Vice-President, A. A. Packard, Chicago, Ill.; Second Vice-President, Richard Fourehy, Kansas City, Mo.; Secretary-Treasurer, Levi R. Whitted, St. Louis, Mo.; Corresponding Secretary, W. D. Windom, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The regular meeting of Feb. 8 in New York City will be devoted to the dedication of a bronze memorial tablet to the society's first president, Dr. Robert H. Thurston. Among those expected to give addresses touching upon Dr. Thurston's character and life work are Prof. John E. Sweet, of Syracuse, N. Y.; Col. E. A. Stevens, of Hoboken, N. J.; Mr. J. G. Schurman, President of Cornell University; Mr. Albert W. Smith, Dr. Thurston's successor as Director of Sibley College; and Mr. William Kent, of New York City. Mr. Alex. C. Humphreys, President of Stevens Institute, will preside at this meeting.

The Thurston memorial tablet to be unveiled at this meeting is the work of Mr. Herman H. McNeil, a former student and personal friend of Dr. Thurston. It is a replica of the tablet presented to Sibley College, Cornell University, by alumni and students. The present tablet has been secured for the rooms of the society through contributions received from members.

Robert Henry Thurston was born in Providence, R. I., in 1839 and was a graduate of Brown University. Before becoming Director of Sibley College, he was, successively, an engineer in the U. S. Navy and Professor of Mechanical Engineering at Stevens Institute. His death occurred in 1903.